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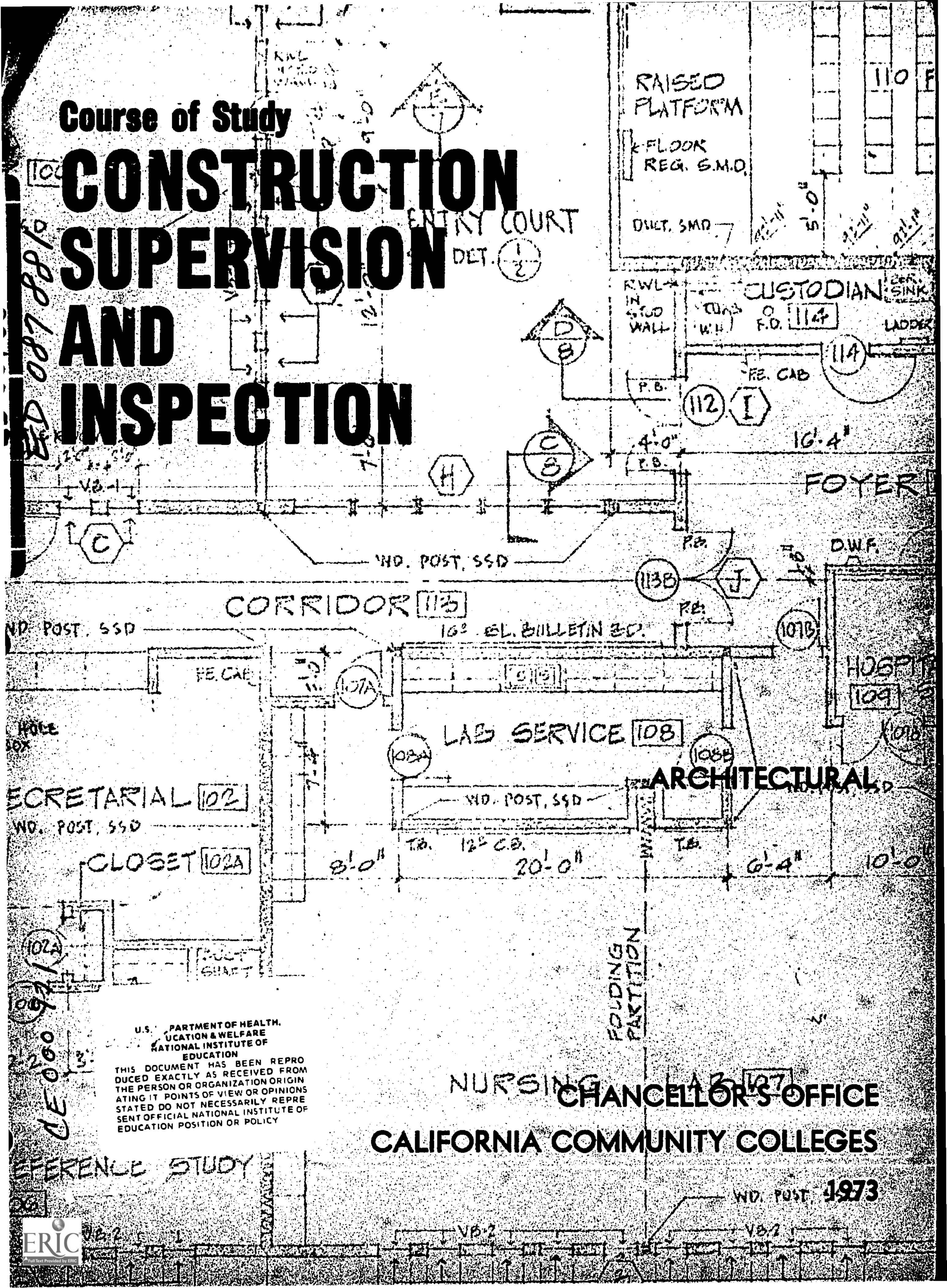
ABSTRACT

This architectural course of study is part of a construction, supervision, and inspection series, which provides instructional materials for community or junior college technical courses in the inspection program. Material covered pertains to: construction contracts, schedules, and site preparation; footings and foundations; masonry and reinforcing steel; wood and drywall; lathing and plastering; plumbing and air conditioning; doors, hardware, paints, floor finishes, ceilings, and specialties; preliminary and final inspections. Many charts and documents are interspersed throughout the document to assist the reader. The course of study may contain more material than can be covered in one semester. (EA)



ED 087 881

Course of Study

CONSTRUCTION SUPERVISION AND INSPECTION

ARCHITECTURAL

CHANCELLOR'S OFFICE

CALIFORNIA COMMUNITY COLLEGES

1973

Course of Study

CONSTRUCTION SUPERVISION AND INSPECTION

ARCHITECTURAL

by

Frank Robson

for the

CHANCELLOR'S OFFICE
CALIFORNIA COMMUNITY COLLEGES
SACRAMENTO
1973

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CONSTRUCTION SUPERVISION AND INSPECTION SERIES

Structural Series No. 1	1966
Structural Series No. 2	1967
Electrical Series No. 1	1972
Air Conditioning, Heating and Ventilating	1973
Architectural	1973
Plumbing and Piping	1973

FOREWORD

The construction industry of today uses a great variety of materials, machines, and processes as well as professional, technical, skilled craftsmen, and building trades to accomplish desired results. A significant role in the construction process required to assure the highest degree of conformity to plans is that of the construction inspector.

As construction practice becomes more complex, the inspector must possess a higher level of competency. Community College construction inspection programs are assisting industry by providing necessary educational programs.

This publication is another in the Construction Supervision and Inspection series. This series was undertaken to provide instructional materials for all technical courses in the inspection program. Each publication is developed by a Community College in cooperation with the Chancellor's Office. Valuable assistance is provided by advisory committees representing architects, engineers, inspectors, contractors, material and equipment manufacturers and suppliers, building trades, and college staff. This series should provide the basis for a comprehensive program.

S. W. Brossman

Sidney W. Brossman, Chancellor
California Community Colleges

PREFACE

This publication provides a comprehensive treatment of material usually covered in an architectural inspection course. As with other publications in the Construction Supervision and Inspection series, it is in draft form and will be refined after it has been used and evaluated by instructors, students, and practitioners. The publication may contain more material than can be covered in one semester. Students may find portions useful beyond the classroom, since it contains reference information. We welcome your comments and suggestions.

I wish to express my appreciation to the author, Frank Robson, who has taught several courses in the Construction Supervision and Inspection program at American River College, and to the advisory committee that assisted him.

Leland P. Baldwin

Leland P. Baldwin, Assistant Chancellor
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The advisory committee, comprised of members listed below, contributed direction and constructive critique during the preparation of the course of study.

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CHAPTER I

RELATIONSHIP AND RESPONSIBILITIES OF ARCHITECT/ENGINEER, OWNER AND CONTRACTOR-LABOR

Inspector's Administrative Responsibilities

Prior to starting a construction project it is necessary to clearly define lines of authority, both the Contractor's and the Owner's. The Owner may be a corporation with a board of directors or an individual. However, to maintain an orderly and uncomplicated chain of command the Inspector should not have to report to more than one or two individuals representing the Owner and deal with only one or two individuals representing the Contractor. This is usually the Project Superintendent and Project Foreman for the Contractor, the Architect/Engineer for a corporation or the individual owner.

All agreements and policies should be in writing and clearly understood by the Contractor and Inspector. The Contractor should submit a schedule of the work to be performed, showing his planned progress for each major item including contract dollar value. This method is used to determine whether or not the Contractor is on schedule and also for estimating progress payments based upon percentage of completion.

A daily diary should be maintained by the Inspector with all pertinent events, actions, discussions with the Contractor's Representative and the Owner, weather conditions, number of personnel on the job site, major material deliveries and any important accomplishments. This record is used to prepare the weekly report to the Architect/Engineer or Owner. It is also used in the event of a Contractor claim. This is the only official document the Architect/Engineer or Owner has to evaluate Contractor claims for additional time or changed conditions.

The weekly report should summarize the week's work progress, any lost time due to weather, shortage of materials, lack of adequate crafts on the job, special meetings, any problems that occurred or are anticipated and any change orders that may be forthcoming due to field conditions.

Change orders are the authorization to the Contractor to add, delete or correct something not covered by the original contract. Change orders usually arise out of unforeseen field conditions. When a change order appears imminent, the Inspector contacts the Architect/Engineer and informs him of the requirement. Normally, the Inspector is required to prepare a field sketch outlining the problem and the proposed solution, together with a list of materials, crafts involved and time to perform the work. The Architect/Engineer evaluates this information. If the problem is structural and of a serious nature the Architect/Engineer will visit the site and either confirm the Inspector's report or reevaluate it. The Architect/Engineer then prepares the necessary drawings, cost estimate and change order to the Contractor and submits them to the Owner for approval. This assures the Contractor payment for the work.

Shop drawings approved by the Architect/Engineer should be in the possession of the Inspector so that he can inspect materials and workmanship on the site.

Permits required by the State, City or County must be in the possession of the Contractor before construction begins. The cost of permits is included in the contract price. The Inspector should check this and see that all required permits are properly posted in accordance with local ordinances.

Certificates of Insurance are usually checked by the Architect/Engineer or the Owner's attorney prior to award of contract. The prime Contractor and all Sub-Contractors must be insured to the limits established by the contract and by law. A complete list of all Sub-Contractors should be furnished the Inspector so that he can prevent Sub-Contractors from working on the job site until their insurance is verified by the Architect/Engineer or Owner.

Performance Bond is submitted to the Owner prior to award of contract. This is a guarantee by an insurance company that the Contractor will perform the work in accordance with the contract and that if the Contractor fails to complete the work within a reasonable time, the Bonding Company will assume the responsibility and will complete the contract. The Bonding Company can perform the work in several ways. One method is to assume the management of the Contractor's organization on the site and direct the completion of the work or in some instances they may contract with an entirely new Contractor to finish the work. In either event, the Owner is guaranteed his project will be completed.

Labor-Management Relations

The Architect/Engineer, Inspector and Owner rarely, if ever, take part in any labor disputes. Any labor problem that may arise on a construction job is the sole responsibility of the Contractor and the Labor Union to solve. The Inspector never, under any circumstances, enters into or even comments upon any

Union matters. The Inspector must never offer an opinion or give an opinion if asked for one, to the Contractor or the Union Representative. The Architect/Engineer, Inspector and Owner must maintain an isolated, independent position when disputes arise.

It is necessary that the Architect/Engineer and Owner be advised when labor problems arise. The Inspector should enter the incidents in his daily diary and notify the Architect/Engineer immediately. Prolonged disagreements could cause a project to be shut down and delayed which may have an economic impact upon the Owner due to delayed occupancy.

Although the position of the Architect/Engineer, Inspector and Owner is primarily as an interested bystander, the impact of their involvement in Union disputes could cause costly construction delays. It is necessary that they understand the relationship between the Unions and the Contractors to include problems that usually cause disputes.

Disputes generally arise from three major grievances for which the Union will bring charges against the Contractor:

1. Union charges unsatisfactory working conditions.

2. Union charges use of non-Union personnel while construction is still in progress.

3. Union charges use of personnel in crafts other than their work permits.

There are two major grievances for which the Contractor will generally bring charges against the Union:

1. Contractor charges that the building trades are featherbedding.

2. Contractor charges that the building trades have slowed down to less than a normal day's work output in order to stretch the work out over a longer period of time.

There is one major area of dispute between the Unions themselves that could, and does in many cases, cause a work stoppage until settled and that is a jurisdictional dispute between trade unions. This occurs generally when new products are introduced into a project and two or more trades claim that the work falls within their boundaries.

Unions and Contractors are each represented on the project. The Union Locals are representatives of the AFL-CIO. Each Local on the project is represented by a Union Steward who, in addition to his regular job, represents the Local Union to see that all the conditions of the contract between the Contractor and the Union are met. Each Local also has a Business Agent who visits the construction projects within his territory. The Business Agent generally deals with the Project Superintendent and if he decides that the Union contract with the Contractor is not being complied with he has the authority to withdraw the members of his Local from the project.

The Building Trades Unions combine to form Building Trades Councils. These councils negotiate with the Contractors' Associations and have the power to call a strike on construction projects. The Councils also solve jurisdictional disputes between the crafts, establish general policy and settle other inter-union problems.

The Contractors also have representation by forming their own associations so that they have better bargaining power. The Associated General Contractors (AGC) is one example.

The Architect/Engineer, Inspector and Owner can help avert possible disputes by insisting the Contractor provide the necessary sanitation facilities and enforce safety regulations.

CHAPTER II

DESIGN AND CONSTRUCTION RESPONSIBILITIES AND CONTRACTS

Design and Construction Responsibilities

The responsibility for the design of buildings and structures rests solely upon the Architect/Engineer, commissioned by principals of organizations or individual owners. His responsibility is to design a facility and certify that it meets all applicable Safety Codes, Building Codes, Health and Industrial Safety Codes, Fire Protection and Prevention Codes, etc., before, during and after construction. The design must be functional and capable of supporting the operations and missions dictated by the Principals or Owners, and to assure that after design, the construction is performed to meet these requirements. The Architect/Engineer prepares in addition to the plans and details of construction, contract documents consisting of specifications which describe the features of the work to be performed, the materials to be incorporated into the work, the finishes and the Guarantees and Warrantees expected to be supplied for special items, workmanship and mechanical items. Usually the Architect/Engineer is required to include an estimate of cost for the building or structure and an estimate of time required to complete the work. Although in many instances the Architect/Engineer will be required to prepare the Invitation for Bid, General and Special Conditions, there are times when the Principal or Owner will prefer his own attorney to perform this function. At any rate, the Architect/Engineer is usually required to work with the attorney and review the final contract documents before the invitation goes out for bid. It is also the Architect/Engineer's responsibility to assist the Principals or Owners in selecting a qualified Contractor.

Types of Contracts

There are several types of construction contracts that are utilized by industry. The two types most commonly used are:

1. LUMP SUM, BID PRICE
2. COST PLUS FIXED FEE

1. LUMP SUM, BID PRICE: This is the type of bid where Contractors submit their proposals in accordance with the plans, specifications and contract documents on a secret, competitive basis. The bids are opened on a specified date, time and place. Usually these bids are opened publicly. If the Contractor submitting the lowest bid meets all the provisions of the Invitation to Bid he should be awarded the contract. This is the most common method used and generally the most economical for the Principals or Owners.

2. COST PLUS FIXED FEE: This type of contract provides that a Contractor agree to a fixed amount or percentage of the actual cost of the construction. This type of contract is usually consumated by requesting selected Contractors to submit proposals. It can also be advertised and usually states that the contract is subject to negotiation which means that the Principals or Owners' negotiating party will make every effort to obtain the most favorable terms by interviewing and discussing the contract with each Contractor selected. This type of contract generally provides a higher cost than the Lump Sum competitively bid contract. However, where construction is of a very complex nature or not normally encountered by Contractors, this type may be an advantage. It takes all the risk out for the Contractor--he would not be bidding excessively high to cover the unfamiliar or inexperienced type of project. By the same token, there is no incentive for the Contractor to economize on materials, construction methods or equipment, especially if the contract is for a percentage of the cost of construction. This type of contract must be carefully entered into, with highly qualified Contractors experienced in this type of contractural obligation.

Inspectors

The Inspector is responsible to observe, maintain records, and report progress of the work. He usually reports to the Architect/Engineer. His authority is assigned usually by letter to the Inspector and the Contractor outlining in brief the action he may or may not take in connection with the contract. Depending upon the experience of the Inspector, the authority to approve changes in the contract on the site may be very limited. On the other hand a very experienced Inspector may be appointed the Architect/Engineer or Owner Representative with authority to approve or disapprove features of work and in many instances make minor changes that do not effect the structural features of the building and restricted usually to a dollar limitation. The Inspector or Representative must be completely conversant with the plans, specifications and contract documents, must coordinate the work with the Contractor's Superintendent in accordance with the work schedule that has been proposed by the Contractor and approved by the Architect/Engineer. The Inspector recommends partial payment to the Contractor. The Inspector and the Contractor's Superintendent jointly review the work progress and agree upon the percentages of completion before a partial payment is submitted. The Inspector maintains a daily diary, weekly reports and a complete file of plans, specifications, shop drawings, materials received at the job site and change authorizations.

Duties, Responsibilities and Limitations of Authority of Full Time Project Representative (AIA) - See Addendum I

Contract Documents

Many contracts are awarded by the Government. The General Conditions, Special Conditions and weekly reports required are basically the same as with private industry. The following Government Contract Documents are included only as a guide. Each Contract has its own specific documents and must be carefully studied and understood by the Inspector.

General Conditions of the Contract for Construction (AIA)

See Addendum II

Index to Technical Specifications Developed by the "Construction Specifications Institute, Inc"

See Addendum III

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GENERAL PROVISIONS

(Construction Contract)

1. DEFINITIONS

(a) The term "head of the agency" or "Secretary" as used herein means the Secretary, the Under Secretary, any Assistant Secretary, or any other head or assistant head of the executive or military department or other Federal agency; and the term "his duly authorized representative" means any person or persons or board (other than the Contracting Officer) authorized to act for the head of the agency or the Secretary.

(b) The term "Contracting Officer" as used herein means the person executing this contract or behalf of the Government and includes a duly appointed successor or authorized representative.

2. SPECIFICATIONS AND DRAWINGS

The Contractor shall keep on the work a copy of the drawings and specifications and shall at all times give the Contracting Officer access thereto. Anything mentioned in the specifications and not shown on the drawings, or shown on the drawings and not mentioned in the specifications, shall be of like effect as if shown or mentioned in both. In case of difference between drawings and specifications, the specifications shall govern. In case of discrepancy either in the figures, in the drawings, or in the specifications, the matter shall be promptly submitted to the Contracting Officer, who shall promptly make a determination in writing. Any adjustment by the Contractor without such a determination shall be at his own risk and expense. The Contracting Officer shall furnish from time to time such detail drawings and other information as he may consider necessary, unless otherwise provided.

3. CHANGES

(a) The Contracting Officer may, at any time, without notice to the sureties, by written order designated or indicated to be a change order, make any change in the work within the general scope of the contract, including but not limited to changes:

(i) In the specifications (including drawings and designs);
(ii) In the method or manner of performance of the work;

(iii) In the Government-furnished facilities, equipment, materials, services, or site; or

(iv) directing acceleration in the performance of the work.

(b) Any other written order or an oral order (which terms as used in this paragraph (b) shall include direction, instruction, interpretation, or determination) from the Contracting Officer, which causes any such change, shall be treated as a change order under this clause, provided that the Contractor gives the Contracting Officer written notice stating the date, circumstances, and source of the order and that the Contractor regards the order as a change order.

(c) Except as herein provided, no order, statement, or conduct of the Contracting Officer shall be treated as a change under this clause or entitle the Contractor to an equitable adjustment hereunder.

(d) If any change under this clause causes an increase or decrease in the Contractor's cost of, or the time required for, the performance of any part of the work under this contract, whether or not changed by any order, an equitable adjustment shall be made and the contract modified in writing accordingly: Provided, however, That except for claims based on defective specifications, no claim for any change under (b) above shall be allowed for any costs incurred more than 20 days before the Contractor gives written notice as therein required: And provided further, That in the case of defective specifications for which the Government is responsible, the equitable adjustment shall include any increased cost reasonably incurred by the Contractor in attempting to comply with such defective specifications.

(e) If the Contractor intends to assert a claim for an equitable adjustment under this clause, he must, within 30 days after receipt of a written change order under (a) above or the furnishing of a written notice under (b) above, submit to the Contracting Officer a written statement setting forth the general nature and monetary extent of such claim, unless this period is extended by the Government. The statement of claim hereunder may be included in the notice under (b) above.

(f) No claim by the Contractor for an equitable adjustment hereunder shall be allowed if asserted after final payment under this contract.

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4. DIFFERING SITE CONDITIONS

(a) The Contractor shall promptly, and before such conditions are disturbed, notify the Contracting Officer in writing of: (1) Subsurface or latent physical conditions at the site differing materially from those indicated in this contract, or (2) unknown physical conditions at the site, of an unusual nature, differing materially from those ordinarily encountered and generally recognized as inhering in work of the character provided for in this contract. The Contracting Officer shall promptly investigate the conditions, and if he finds that such conditions do materially so differ and cause an increase or decrease in the Contractor's cost of, or the time required for, performance of any part of the work under this contract, whether or not changed as a result of such conditions, an equitable adjustment shall be made and the contract modified in writing accordingly.

(b) No claim of the Contractor under this clause shall be allowed unless the Contractor has given the notice required in (a) above; provided, however, the time prescribed therefor may be extended by the Government.

(c) No claim by the Contractor for an equitable adjustment hereunder shall be allowed if asserted after final payment under this contract.

5. TERMINATION FOR DEFAULT--DAMAGES FOR DELAY--TIME EXTENSIONS

(a) If the Contractor refuses or fails to prosecute the work, or any separable part thereof with such diligence as will insure its completion within the time specified in this contract, or any extension thereof, or fails to complete said work within such time, the Government may, by written notice to the Contractor, terminate his right to proceed with the work or such part of the work as to which there has been delay. In such event the Government may take over the work and prosecute the same to completion, by contract or otherwise, and may take possession of and utilize in completing the work such materials, appliances, and plant as may be on the site of the work and necessary therefor. Whether or not the Contractor's right to proceed with the work is terminated, he and his sureties shall be liable for any damage to the Government resulting from his refusal or failure to complete the work within the specified time.

EXACT COPY

(b) If fixed and agreed liquidated damages are provided in the contract and if the Government so terminates the Contractor's right to proceed, the resulting damage will consist of such liquidated damages until such reasonable time as may be required for final completion of the work together with any increased costs occasioned the Government in completing the work.

(c) If fixed and agreed liquidated damages are provided in the contract and if the Government does not so terminate the Contractor's right to proceed, the resulting damage will consist of such liquidated damages until the work is completed or accepted.

(d) The Contractor's right to proceed shall not be so terminated nor the Contractor charged with resulting damage if:

(1) The delay in the completion of the work arises from unforeseeable causes beyond the control and without the fault or negligence of the Contractor, including but not restricted to, acts of God, acts of the public enemy, acts of the Government in either its soverign or contractural capacity, acts of another contractor in the performance of a contract with the Government, fires, floods, epidemics, quarantine restrictions, strikes, freight embargoes, unusually severe weather, or delays of subcontractors or suppliers arising from unforeseeable causes beyond the control and without the fault or negligence of both the Contractor and such subcontractors or suppliers; and

(2) The Contractor, within 10 days from the beginning of any such delay (unless the Contracting Officer grants a further period of time before the date of final payment under the contract), notifies the Contracting Officer in writing of the causes of delay.

The Contracting Officer shall ascertain the facts and the extent of the delay and extend the time for completing the work when, in his judgment, the findings of fact justify such an extension, and his findings of fact shall be final and conclusive on the parties, subject only to appeal as provided in Clause 6 of these General Provisions.

(e) If, after notice of termination of the Contractor's right to proceed under the provisions of this clause, it is determined for any reason that the Contractor was not in default under the provisions of this clause, or that the delay was excusable under the provisions of this clause, the rights and obligations of the parties shall, if the contract contains a clause providing for termination for convenience of the Government, be the same as if the notice of termination had been issued pursuant to such clause. If, in the foregoing circumstances, this contract does not contain a clause providing for termination for convenience of the Government, the contract shall be equitably adjusted to compensate for such termination and the contract modified accordingly; failure to agree to any such adjustment shall be a dispute concerning a question of fact within the meaning of the clause of this contract entitled "Disputes."

(f) The rights and remedies of the Government provided in this clause are in addition to any other rights and remedies provided by law or under this contract.

(g) As used in Paragraph (d)(1) of this clause, the term 'Subcontractors or Suppliers' means Subcontractors or Suppliers at any tier.

6. DISPUTES

(a) Except as otherwise provided in this contract, any dispute concerning a question of fact arising under this contract which is not disposed of by agreement shall be decided by the Contracting Officer, who shall reduce his decision to writing and mail or otherwise furnish a copy thereof to the Contractor. The decision of the Contracting Officer shall be final and conclusive unless, within 30 days from the date of receipt of such copy, the Contractor mails or otherwise furnishes to the Contracting Officer a written appeal addressed to the head of the agency involved. The decision of the head of the agency or his duly authorized representative for the determination of such appeals whall be final and conclusive. This provision shall not be pleaded in any suit involving a question of fact arising under this contract as limiting judicial review of any such decision to cases where fraud by such official or his representative or board is alleged: Provided, however, That any such decision shall be final and conclusive unless the same is fraudulent or capricious or arbitrary or so grossly erroneous as necessarily to imply bad faith or is not supported by substantial evidence. In connection with any appeal proceeding under this clause, the

Contractor shall be afforded an opportunity to be heard and to offer evidence in support of his appeal. Pending final ~~decision~~ decision of a dispute hereunder, the Contractor shall proceed diligently with the performance of the contract and in accordance with the Contracting Officer's decision.

(b) This Disputes clause does not preclude consideration of questions of law in connection with decisions provided for in paragraph (a) above. Nothing in this contract, however, shall be construed as making final the decision of any administrative official, representative, or board on a question of law.

7. PAYMENTS TO CONTRACTOR

(a) The Government will pay the contract price as hereinafter provided.

(b) The Government will make progress payments monthly as the work proceeds, or at more frequent intervals as determined by the Contracting Officer, on estimates approved by the Contracting Officer. If requested by the Contracting Officer, the Contractor shall furnish a breakdown of the total contract price showing the amount included therein for each principal category of the work, in such detail as requested, to provide a basis for determining progress payments. In the preparation of estimates the Contracting Officer, at his discretion, may authorize material delivered on the site and preparatory work done to be taken into consideration. Material delivered to the Contractor at locations other than the site may also be taken into consideration (1) if such consideration is specifically authorized by the contract and (2) if the Contractor furnishes satisfactory evidence that he has acquired title to such material and that it will be utilized on the work covered by this contract.

(c) In making such progress payments, there shall be retained 10 percent of the estimated amount until final completion and acceptance of the contract work. However, if the Contracting Officer, at any time after 50 percent of the work has been completed, finds that satisfactory progress is being made, he may authorize any of the remaining progress payments to be made in full. Also, whenever the work is substantially complete, the Contracting Officer, if he considers the amount retained to be in excess of the amount adequate for the protection of the Government, at his discretion, may release to the Contractor all or a portion of such excess amount. Furthermore, on completion and acceptance of each separate building, public work, or other division of the contract, on which the price is stated separately in the contract, payment may be made therefor without retention of a percentage.

(d) All material and work covered by progress payments made shall thereupon become the sole property of the Government, but this provision shall not be construed as relieving the Contractor from the sole responsibility for all material and work upon which payments have been made or the restoration of any damaged work, or as waiving the right of the Government to require the fulfillment of all of the terms of the contract.

(e) Upon completion and acceptance of all work, the amount due the Contractor under this contract shall be paid upon the presentation of a properly executed voucher and after the Contractor shall have furnished the Government with a release, if required, of all claims against the Government arising by virtue of this contract, other than claims in stated amounts as may be specifically excepted by the Contractor from the operation of the release. If the Contractor's claim to amounts payable under the contract has been assigned under the Assignment of Claims Act of 1940, as amended (31 U.S.C. 203, 41 U.S.C. 15), a release may also be required of the assignee.

8. ASSIGNMENT OF CLAIMS

(a) Pursuant to the provisions of the Assignment of Claims Act of 1940, as amended (31 U.S.C. 203, 41 U.S.C. 15), if this contract provides for payments aggregating $1,000 or more, claims for moneys due or to become due the Contractor from the Government under this contract may be assigned to a bank, trust company, or other financing institution, including any Federal lending agency, and may thereafter be further assigned and reassigned to any such institution. Any such assignment or reassignment shall cover all amounts payable under this contract and not already paid, and shall not be made to more than one party, except that any such assignment or reassignment may be made to one party as agent or trustee for two or more parties participating in such financing. Unless otherwise provided in this contract, payments to an assignee of any moneys due or to become due under this contract shall not, to the extent provided in said Act, as amended, be subject to reduction or setoff. (The preceding sentence applies only if this contract is made in time of war or national emergency as defined in said Act; and is with the Department of Defense, the General Services Administration, the Atomic Energy Commission, the National Aeronautics and Space Administration, the Federal Aviation Agency, or any other department or agency of the United States designated by the President pursuant to Clause 4 of the proviso of section 1 of the Assignment of Claims Act of 1940, as amended by the Act of May 15, 1951, 65 Stat. 41).

(b) In no event shall copies of this contract or of any plans, specifications, or other similar documents relating to work under this contract, if marked "Top Secret," "Secret," or "Confidential," be furnished to any assignee of any claim arising under this contract or to any other person not entitled to receive the same. However, a copy of any part or all of this contract so marked may be furnished, or any information contained therein may be disclosed, to such assignee upon the prior written authorization of the Contracting Officer.

9. MATERIAL AND WORKMANSHIP

(a) Unless otherwise specifically provided in this contract, all equipment, material and articles incorporated in the work covered by this contract are to be new and of the most suitable grade for the purpose intended. Unless otherwise specifically provided in this contract, reference to any equipment, material, article, or patented process, by trade name, make, or catalog number, shall be regarded as establishing a standard of quality and shall not be construed as limiting competition, and the Contractor may, at his option, use any equipment, material, article, or process which, in the judgment of the Contracting Officer, is equal to that named. The Contractor shall furnish to the Contracting Officer for his approval the name of the manufacturer, the model number, and other identifying data and information respecting the performance, capacity, nature, and rating of the machinery and mechanical and other equipment which the Contractor contemplates incorporating in the work. When required by this contract or when called for by the Contracting Officer, the Contractor shall furnish the Contracting Officer for approval full information concerning the material or articles which he contemplates incorporating in the work. When so directed, samples shall be submitted for approval at the Contractor's expense, with all shipping charges prepaid. Machinery, equipment, material, and articles installed or used without required approval shall be at the risk of subsequent rejection.

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(b) All work under this contract shall be performed in a skillful and workmanlike manner. The Contracting Officer may, in writing, require the Contractor to remove from the work any employee the Contracting Officer deems incompetent, careless, or otherwise objectionable.

10. INSPECTION AND ACCEPTANCE

(a) Except as otherwise provided in this contract, inspection and test by the Government of material and workmanship required by this contract shall be made at reasonable times and at the site of the work, unless the Contracting Officer determines that such inspection or test of material which is to be incorporated in the work shall be made at the place of production, manufacture, or shipment of such material. To the extent specified by the Contracting Officer at the time of determining to make off-site inspection or test, such inspection or test shall be conclusive as to whether the material involved conforms to the contract requirements. Such off-site inspection or test shall not relieve the Contractor of responsibility for damage to or loss of the material prior to acceptance, nor in any way affect the continuing rights of the Government after acceptance of the completed work under the terms of paragraph (f) of this clause, except as hereinabove provided.

(b) The Contractor shall, without charge, replace any material or correct any workmanship found by the Government not to conform to the contract requirements, unless in the public interest the Government consents to accept such material or workmanship with an appropriate adjustment in contract price. The Contractor shall promptly segregate and remove rejected material from the premises.

(c) If the Contractor does not promptly replace rejected material or correct rejected workmanship, the Government (1) may, by contract or otherwise, replace such material or correct such workmanship and charge the cost thereof to the Contractor, or (2) may terminate the Contractor's right to proceed in accordance with Clause 5 of these General Provisions.

(d) The Contractor shall furnish promptly, without additional charge, all facilities, labor, and material reasonably needed for performing such safe and convenient inspection and test as may be required by the Contracting Officer. All inspection and test by the Government shall be performed in such manner as not unnecessarily to delay the work. Special, full size, and performance tests shall be performed as described in this contract. The Contractor shall be charged with any additional cost of inspection when material and workmanship are not ready at the time specified by the Contractor for its inspection.

(e) Should it be considered necessary or advisable by the Government at any time before acceptance of the entire work to make an examination of work already completed, by removing or tearing out same, the Contractor shall, on request, promptly furnish all necessary facilities, labor, and material. If such work is found to be defective or nonconforming in any material respect, due to the fault of the Contractor or his subcontractors, he shall defray all the expenses of such examination and of satisfactory reconstruction. If, however, such work if found to meet the requirements of the contract, an equitable adjustment shall be made in the contract price to compensate the Contractor for the additional services involved in such examination and reconstruction and, if completion of the work has been delayed thereby, he shall, in addition, be granted a suitable extension of time.

(f) Unless otherwise provided in this contract, acceptance by the Government shall be made as promptly as practicable after completion and inspection of all work required by this contract. Acceptance shall be final and conclusive except as regards latent defects, fraud, or such gross mistakes as may amount to fraud, or as regards the Government's rights under any warranty or guarantee.

11. SUPERINTENDENCE BY CONTRACTOR

The Contractor shall give his personal superintendence to the work or have a competent foreman or superintendent, satisfactory to the Contracting Officer, on the work at all times during progress, with authority to act for him.

12. PERMITS AND RESPONSIBILITIES

The Contractor shall, without additional expense to the Government, be responsible for obtaining any necessary licenses and permits, and for complying with any applicable Federal, State, and municipal laws, codes, and regulations in connection with the prosecution of the work. He shall be similarly responsible for all damages to persons or property that occur as a result of his fault or negligence. He shall take proper safety and health precautions to protect the work, the workers, the public, and the property of others. He shall also be responsible for all materials delivered and work performed until completion and acceptance of the entire construction work, except for any completed unit of construction thereof which theretofore may have been accepted.

13. CONDITIONS AFFECTING THE WORK

The Contractor shall be responsible for having taken steps reasonably necessary to ascertain the nature and location of the work, and the general and local conditions which can affect the work or the cost thereof. Any failure by the Contractor to do so will not relieve him from responsibility for successfully performing the work without additional expense to the Government. The Government assumes no responsibility for any understanding or representations concerning conditions made by any of its officers or agents prior to the execution of this contract, unless such understanding or representations by the Government are expressly stated in the contract.

14. OTHER CONTRACTS

The Government may undertake or award other contracts for additional work, and the Contractor shall fully cooperate with such other contractors and Government employees and carefully fit his own work to such additional work as may be directed by the Contracting Officer. The Contractor shall not commit or permit any act which will interfere with the performance of work by any other contractor or by Government employees.

15. PATENT INDEMNITY

Except as otherwise provided, the Contractor agrees to indemnify the Government and its officers, agents, and employees against liability, including costs and expenses, for infringement upon any Letters Patent of the United States (except Letters Patent issued upon an application which is now or may hereafter be, for reasons of national security, ordered by the Government to be kept secret or otherwise withheld from issue) arising out of the performance of this contract or out of the use or disposal by or for the account of the Government of supplies furnished or construction work performed hereunder.

EXACT COPY

16. ADDITIONAL BOND SECURITY

If any surety upon any bond furnished in connection with this contract becomes unacceptable to the Government, or if any such surety fails to furnish reports as to his financial condition from time to time as requested by the Government, the Contractor shall promptly furnish such additional security as may be required from time to time to protect the interests of the Government and of persons supplying labor or materials in the prosecution of the work contemplated by this contract.

17. COVENANT AGAINST CONTINGENT FEES

The Contractor warrants that no person or selling agency has been employed or retained to solicit or secure this contract upon an agreement or understanding for a commission, percentage, brokerage, or contingent fee, excepting bona fide employees or bonafide established commercial or selling agencies maintained by the Contractor for the purpose of securing business. For breach or violation of this warranty the Government shall have the right to annul this contract without liability or in its discretion to deduct from the contract price or consideration, or otherwise recover, the full amount of such commission, percentage, brokerage, or contingent fee.

18. OFFICIALS NOT TO BENEFIT

No member of Congress or resident Commissioner shall be admitted to any share or part of this contract or to any benefit that may arise therefrom; but this provision shall not be construed to extend to this contract if made with a corporation for its general benefit.

19. BUY AMERICAN

(a) Agreement. In accordance with the Buy American Act (41 U.S.C. 10a-10d), and Executive Order 10582, December 17, 1954 (3 CFR, 1954-58 Comp., p. 230), as amended by Executive Order 11051, September 27, 1962 (3 CFR, 1959-63 Comp., p. 635), the Contractor agrees that only domestic construction material will be used (by the Contractor, subcontractors, materialmen, and suppliers) in the performance of this contract, except for nondomestic material listed in the contract.

EXACT COPY

(b) Domestic construction material. "Construction material" means any article, material, or supply brought to the construction site for incorporation in the building or work. An unmanufactured construction material is a "domestic construction material" if it has been mined or produced in the United States. A manufactured construction material is a "domestic construction material" if it has been manufactured in the United States and if the cost of its components which have been mined, produced, or manufactured in the United States exceeds 50 percent of the cost of all its components. "Component" means any article, material, or supply directly incorporated in a construction material.

(c) Domestic component. A component shall be considered to have been "mined, produced, or manufactured in the United States" (regardless of its source in fact) if the article, material, or supply in which it is incorporated was manufactured in the United States and the component is of a class or kind determined by the Government to be not mined, produced, or manufactured in the United States in sufficient and reasonably available commercial quantities and of a satisfactory quality.

20. CONVICT LABOR

In connection with the performance of work under this contract, the Contractor agrees not to employ any person undergoing sentence of imprisonment at hard labor.

21. EQUAL OPPORTUNITY

(The following clause is applicable unless this contract is exempt under the rules, regulations, and relevant orders of the Secretary of Labor (41 CFR, ch. 60).

During the performance of this contract, the Contractor agrees as follows:

(a) The Contractor will not discriminate against any employee or applicant for employment because of race, color, religion, sex, or national origin. The Contractor will take affirmative action to ensure that applicants are employed, and that employees are treated during employment, without regard to their race, color, religion, sex, or national origin. Such action shall include, but not be limited to the following: Employment, upgrading, demotion, or transfer;

recruitment or recruitment advertising; layoff or termination; rates of pay or other forms of compensation; and selection for training, including apprenticeship. The Contractor agrees to post in conspicuous places, available to employees and applicants for employment, notices to be provided by the Contracting Officer setting forth the provisions of this Equal Opportunity clause.

(b) The Contractor will, in all solicitations or advertisements for employees placed by or on behalf of the Contractor, state that all qualified applicants will receive consideration for employment without regard to race, color, religion, sex, or national origin.

(c) The Contractor will send to each labor union or representative of workers with which he has a collective bargaining agreement or other contract or understanding, a notice, to be provided by the agency Contracting Officer, advising the labor union or workers' representative of the Contractor's commitments under this Equal Opportunity clause, and shall post copies of the notice in conspicuous places available to employees and applicants for employment.

(d) The Contractor will comply with all provisions of Executive Order No. 11246 of September 24, 1965, and of the rules, regulations, and relevant orders of the Secretary of Labor.

(e) The Contractor will furnish all information and reports required by Executive Order No. 11246 of September 24, 1965, and by the rules, regulations, and orders of the Secretary of Labor, or pursuant thereto, and will permit access to his books, records, and accounts by the contracting agency and the Secretary of Labor for purposes of investigation to ascertain compliance with such rules, regulations, and orders.

(f) In the event of the Contractor's noncompliance with the Equal Opportunity clause of this contract or with any of the said rules, regulations, or oders, this contract may be canceled, terminated, or suspended, in whole or in part and the Contractor may be declared ineligible for further Government contracts in accordance with procedures authorized in Executive Order No. 11246 of September 24, 1965, and such other sanctions may be imposed and remedies invoked as provided in Executive Order No. 11246 of September 24, 1965, or by rule, regulation, or order of the Secretary of Labor, or as otherwise provided by law.

EXACT COPY

(g) The Contractor will include the provisions of paragraphs (a) through (g) in every subcontract or purchase order unless exempted by rules, regulations, or orders of the Secretary of Labor issued pursuant to section 204 of Executive Order No. 11246 of September 24, 1965, so that such provisions will be binding upon each subcontractor or vendor. The Contractor will take such action with respect to any subcontract or purchase order as the contracting agency may direct as a means of enforcing such provisions, including sanctions for noncompliance: Provided, however, That in the event the Contractor becomes involved in, or is threatened with, litigation with a subcontractor or vendor as a result of such direction by the contracting agency, the Contractor may request the United States to enter into such litigation to protect the interests of the United States."

22. UTILIZATION OF SMALL BUSINESS CONCERNS

(a) It is the policy of the Government as declared by the Congress that a fair proportion of the purchases and contracts for supplies and services for the Government be placed with small business concerns.

(b) The Contractor agrees to accomplish the maximum amount of subcontracting to small business concerns that the Contractor finds to be consistent with the efficient performance of this contract.

23. SUSPENSION OF WORK

(a) The Contracting Officer may order the Contractor in writing to suspend, delay, or interrupt all or any part of the work for such period of time as he may determine to be appropriate for the convenience of the Government.

(b) If the performance of all or any part of the work is, for an unreasonable period of time, suspended, delayed or interrupted by an act of the Contracting Officer in the administration of this contract, or by his failure to act within the time specified in this contract (or if no time is specified, within a reasonable time), an adjustment shall be made for any increase in the cost of performance of this contract (excluding profit) necessarily caused by such unreasonable suspension, delay, or interruption and the contract modified in writing accordingly. However, no adjustment shall be made under this clause for any suspension, delay, or interruption to the extent (1) that performance would have been so suspended, delayed, or interrupted by any other cause, including the fault or negligence of the Contractor or (2) for which an equitable adjustment is provided for or excluded under any other provision of this contract.

(c) No claim under this clause shall be allowed (1) for any costs incurred more than 20 days before the Contractor shall have notified the Contracting Officer in writing of the act or failure to act involved (but this requirement shall not apply as to a claim resulting from a suspension order), and (2) unless the claim, in an amount stated, is asserted in writing as soon as practicable after the termination of such suspension, delay, or interruption, but not later than the date of final payment under the contract.

SCHEDULE
SPECIAL CONDITIONS

SPECIAL CONDITION NO.	TITLE
SC-1	AFFILIATED BIDDERS
SC-2	NON-DOMESTIC PRODUCTS
SC-3	AVAILABILITY OF UTILITY SERVICES
SC-4	CLEARANCE PRIOR TO EXCAVATION
SC-5	CONDITIONS OF WORK
SC-6	COMMENCEMENT, PROSECUTION AND COMPLETION OF WORK
SC-7	CONTRACT DRAWINGS, MAPS AND SPECIFICATIONS
SC-8	LIQUIDATED DAMAGES
SC-9	PHYSICAL DATA
SC-10	COST LIMITATION
SC-11	IDENTIFICATION OF GOVERNMENT FURNISHED PROPERTY
SC-12	SAMPLES AND DESCRIPTIVE DATA
SC-13	TRANSPORTATION

SCHEDULE
SPECIAL CONDITIONS

SC-1 AFFILIATED BIDDERS (JAN 1961)(ASPR 2-201(a)(xxiii))

(a) Business concerns are affiliates of each other when either directly or indirectly (i) one concern controls or has the power to control the other, or (ii) a third party controls or has the power to control both.

(b) Each bidder shall submit with his bid an affidavit containing information as follows:

(i) whether the bidder has any affiliates;

(ii) the names and adresses of all affiliates of the bidder; and

(iii) the names and addresses of all persons and concerns exercising control or ownership of the bidder and any or all of his affiliates, and whether as common officers, directors, stockholders holding controlling interest or otherwise.

Failure to furnish such an affidavit may result in rejection of the bid.

CHECK ONE OF THE FOLLOWING AND FURNISH SEPARATE AFFIDAVIT IF APPLICABLE:

__________ Affidavit that bidder/offeror is not affiliated with any other firm is attached.

__________ Affidavit supplying information called for above is attached.

SC-2 NON-DOMESTIC PRODUCTS

The bidder herby certifies, except as listed below, that only domestic construction materials will be used in the performance of this contract.

The following non-domestic construction materials will be used in performance of this contract: (None unless specific items are listed below by Bidder): See Additional General Provision No. 4.

PRODUCT	ESTIMATED VALUE	ORIGIN
__________	$__________	__________
__________	$__________	__________

SC-3 AVAILABILITY OF UTILITY SERVICES (See Additional General Provision AGP-26)

All reasonably required amounts of water, gas, electricity, etc., will be made available to the Contractor by the Government from existing system outlets and supplies at no charge to the Contractor in connection with the performance of this contract.

SC-4 CLEARANCE PRIOR TO EXCAVATION

Whenever excavation is required to be performed, clearance shall be obtained from the Post Engineer and the Signal Officer, Sacramento Army Depot, Sacramento, California 95813 prior to commencement of any excavation.

SC-5 CONDITIONS OF WORK

The work to be performed shall be accomplished without unscheduled interruptions to Government operations on the depot. Therefore, where electrical, mechanical connections and/or related work requires shutdown of utility services the Contractor shall obtain clearance from the Contracting Officer's designated representative prior to proceeding with the job.

SCHEDULE
SPECIAL CONDITIONS

SC-6 COMMENCEMENT, PROSECUTION AND COMPLETION OF WORK (JAN. 1965)(ASPR 7-602.44)

The Contractor will be required to commence work under this contract within ____________________ calendar days after the date of receipt by him of notice to proceed, to prosecute said work diligently, and to complete the entire work ready for use not later than ______________________ calendar days after receipt of notice to proceed. The time stated for completion shall include final clean-up of the premises.

SC-7 CONTRACT DRAWINGS, MAPS AND SPECIFICATIONS (JAN 1965)(ASPR 7-602.45)

(a) ________________ sets (five unless otherwise specified herein) of large scale contract drawings, maps and specification will be furnished the Contractor without charge except applicable publications incorporated into the technical provisions by reference. Additional sets will be furnished on request at the cost of reproduction. The work shall conform to the following contract drawings and maps, all of which form a part of these specifications and are available in the office of THE POST ENGINEER, SACRAMENTO ARMY DEPOT, SACRAMENTO, CALIFORNIA 95813

TITLE	FILE	DRAWING NO.

(b) Omissions from the drawings or specifications or the misdescription of details of work which are manifestly necessary to carry out the intent of the drawings and specifications, or which are customarily performed, shall not relieve the Contractor from performing such omitted or misdescribed details of the work but they shall be performed as if fully and correctly set forth and described in the drawings and specifications.

(c) The Contractor shall check all drawings furnished him immediately upon their receipt and shall promptly notify the Contracting Officer of any discrepancies. Figures marked on drawings shall in general be followed in preference to scale measurements. Large scale drawings shall in general govern small scale drawings. The Contractor shall compare all drawings and verify the figures before laying out the work and will be responsible for any errors which might have been avoided thereby.

SC-8 LIQUIDATED DAMGES (JAN 1965)(ASPR 7-603.39)

In case of failure on the part of the Contractor to complete the work within the time fixed in the contract or any extensions thereof, the Contractor shall pay to the Government as liquidated damages, pursuant to the clause of this contract entitled "Terminations for Default - Damages for Delay - Time Extensions", the sum of ________________ for each day of delay.

SC-9 PHYSICAL DATA (JAN 1965)(ASPR 7-603.25)(b))

Information and data furnished or referred to below are furnished for the Contractor's information. However, it is expressly understood that the Government will not be responsible for any interpretation or conclusion drawn therefrom by the Contractor.

(a) The physical conditions indicated on the drawings and in the specifications are the result of site investigations by ____

(b) Weather Conditions. ____

(c) Transportation facilities. ____

(d) ____

SCHEDULE
SPECIAL CONDITIONS

SC-10 COST LIMITATION (APR 1968)(ASPR 2-201(c)(i))

A bid which does not contain separate bid prices for the items identified as subject to a cost limitation may be considered nonresponsive. A bidder by signing his bid certifies that each price bid on items subject to a cost limitation includes an appropriate apportionment of all applicable estimated costs, direct and indirect, as well as overhead and profit. Bids may be rejected which (i) have been materially unbalanced for the purpose of bringing affected items within cost limitations, or (ii) exceed the cost limitations unless such limitations have been waived by the Assistant Secretary of Defense (Installations and Logistics) prior to award.

SC-11 IDENTIFICATION OF GOVERNMENT FURNISHED PROPERTY (JAN 1965)(ASPR 7-603.28)

The Government will furnish to the Contractor the following property to be incorporated or installed in the work or used in its performance. Such property will be furnished F.O.B. railroad cars at the place specified in paragraph __________, or F.O.B. truck at the project site and the Contractor will be required to accept delivery when made, paying any demurrage incurred, and unloading and transporting the property to the job site at his own expense. All such property will be installed or incorporated into the work at the expense of the Contractor, unless otherwise indicated herein. The Contractor shall verify the quantity and condition of such Government-furnished property when delivered to him, acknowledge receipt thereof in writing to the Contracting Officer, and in case of damage to or shortage of such property, he shall within 24 hours report in writing such damage or shortage to the Contracting Officer.

QUANTITY	ITEM	DESCRIPTION

SC-12 SAMPLES AND DESCRIPTIVE DATA

(a) Any samples and descriptive data required shall:

(1) Be submitted within the time specified in these specifications or, if no time be specified, within a reasonable time before use to permit inspection and testing.

(2) Be shipped prepaid and delivered as specified in these specifications, or as directed by the Contracting Officer.

(3) Be properly marked to shown the name of the material, trade name of manufacturer, place of origin, name and location of the work where the material represented by the sample is to be used, and the name of the Contractor submitting the sample.

(b) Samples not subjected to destructive tests may be retained until completion of the work but thereafter will be returned to the Contractor, if he so requests in writing, at his own expense. Failure of any sample to pass the specified requirements will be sufficient cause for refusal to consider further any samples from the same manufacturer whose materials failed to pass the tests.

SC-13 TRANSPORTATION

Where Government switching service is available, and is desired by the Contractor, the same will be provided as requested. Rates therefore will be established by the Government consistent with local prevailing rates in the railroad industry, but in no event at less than full cost to the Government. Accrued charges will be set off against payments otherwise due the Contractor. Appropriate credit for service provided hereunder will be reflected in Contractor's invoice or invoices.

CHAPTER III

CONSTRUCTION SCHEDULES

Construction Schedules should be posted for ready reference. The schedule is prepared by the Contractor, and approved by the Architect/Engineer or Owner. This is the road map for the Inspector to determine whether or not the project is progressing according to an agreed upon schedule. It also provides the Owner with a method of planning his finances for progress payments and forecasting occupancy of the building or structure.

One of the prime values to the Inspector is to be able to determine whether or not the Contractor is on schedule. To do this he must have a time table as well as a road map and this provides both. The essential parts of a Construction Schedule are:

1. Outline construction features of work
2. Projections of time for each major element
3. Percentage value of each salient feature of work
4. Time of completion

The Progress Schedule provides a guide to the Inspector for checking to see that materials and equipment are available in sufficient quantity and within the time frame necessary to complete elements of work within the planned schedule.

There are three basic types of Progress Schedules used:

1. Bar Chart
2. Program Evaluation Review Technology (PERT)
3. Critical Path Method

<u>Bar Chart</u> scheduling is used for all types of projects and can be adapted to most any type of construction. It lends itself particularly well to small projects where there are fewer work elements and fewer activities in progress at the same time. However, Bar Charts are not limited to only small projects--they can be utilized for larger construction as well. The advantages and disadvantages are as follow:

<u>ADVANTAGES</u>

1. Simple to prepare
2. Easy to understand
3. Not limited to project size
4. Can be prepared by the Construction Superintendent, Foreman or others with like experience

DISADVANTAGES

1. Difficult to reschedule because only major crafts are listed
2. Only shows whether or not a craft is on schedule
3. Does not show what caused a delay

Program Evaluation Review Technology (PERT) is utilized primarily for large complicated construction projects where there are fifty or more activities. This program can be used very effectively on large projects where each segment of the work is programmed into activities together with materials and crafts required to perform the work. The activities are separated along a network of scheduled functions which at a glance can be rescheduled ahead or behind the planned progress to insure an uninterrupted flow of work and progress due to late delivery of materials and equipment, unscheduled delays of other crafts or more rapid completion of an activity than anticipated.

ADVANTAGES

1. Very large and complicated construction projects are more easily controlled
2. Delays can be scheduled back into the program without interrupting the progress
3. Specific knowledge of the work progress and easy identification of trouble areas
4. Greater reliability that the project will be completed on schedule

DISADVANTAGES

1. Is not readily adaptable to small projects
2. Requires the Architect/Engineer or skilled construction technicians to prepare
3. Requires knowledgeable personnel to interpret and reschedule properly

The Critical Path Method is the most commonly used in industry today. It is a formal and graphic means of determining the relationships between tasks associated with any project (construction or otherwise). It provides systematic isolation of those tasks that comprise the critical elements which set the duration of that project. Through such a tool the manager can analyze a project before, during, and after operations. Its greatest asset is the portrayal of those tasks which are critical, thus giving the manager a forewarning of where he can expect trouble in meeting schedules.

The Critical Path as such is new. It was first used, about 1958 by the Dupont Company, to determine the time needed to do some construction where the shutdown of machinery for any period unnecessarily long would be unprofitable. By the use of the Critical Path Method much time was cut from both the construction and shutdown time. In 1958 the Navy, confronted with building the Polaris Missile and Submarine, developed the Critical Path Method using a probabilistic approach to allow for research and development factors. The use of this method, called "Program Evaluation Review Technique", is claimed to have cut years from the project. Currently, others in various universities and consulting firms are perfecting variations of both systems to meet a variety of needs. The Critical Path Method in different forms is being used by the Navy, Air Force, Army Corps of Engineers and more and more contractors.

The Critical Path Method of analyzing, planning and scheduling a project must be preceded by the usual determination of the tasks which must be accomplished, or the events which must occur to bring about its successful conclusion. As in the past, this determination is most important. In order to begin application of the Critical Path Method to a project, three simple questions are asked about each task. (1) What task(s) must be accomplished before this one can begin? (2) What tasks can be accomplished while this one is being done? (3) What tasks cannot begin until this one is completed? The answers to these questions will form the basis for drawing a network identifying tasks (activities) or events (milestones) in an ordered sequence of relationships. It should be noted here that the planning is a distinct phase of the operation. Scheduling follows the making of the network.

It was stated in the paragraph above that the questions of precedence, concurrency and succession formed the basis for setting up a network of a project. In effect, this network is a graphic portrayal of the relationships between tasks throughout the entire project. Networks are of two types, the Activity Oriented and the Event Oriented. In the Activity Oriented network each activity is represented by a solid arrow, and in the Event Oriented a circle may represent the event. The difference between the two is simple. An Activity is any time consuming operation. An Event is a point in time. Arrows representing tasks are used to draw the network for the Activity oriented system; whereas, circles joined by lines form the Event oriented network. In the initial drawing of the Event network it is best to use arrows to show flow. In neither case does the length or direction of a line or an arrow have any relationship to value. Arrows are normally drawn from left to right, and vertically up or down, flow being indicated from tail to head. In initial drawing, lines or arrows may run in any direction. (See Figures 3-1 and 3-2)

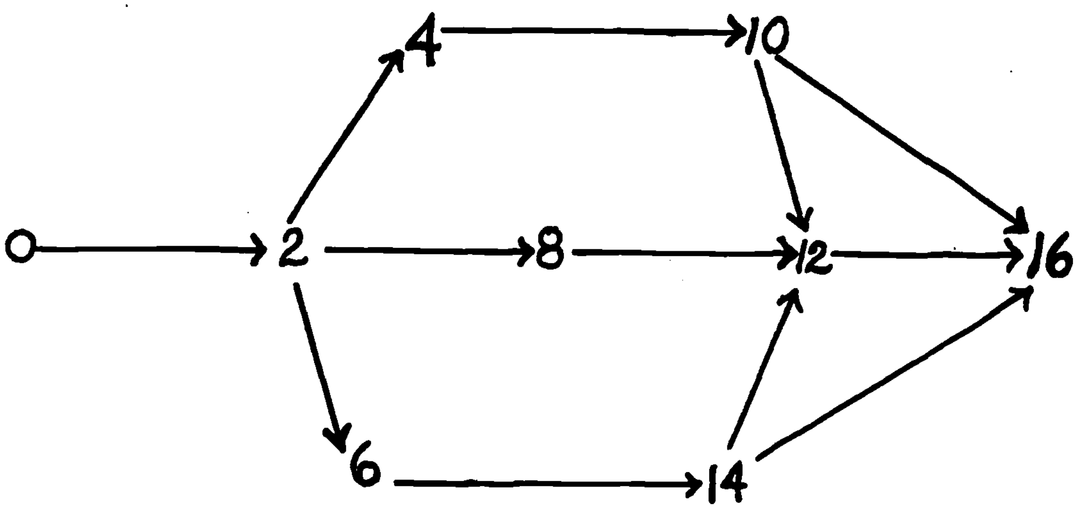


FIGURE 3-1
Activity Oriented Network

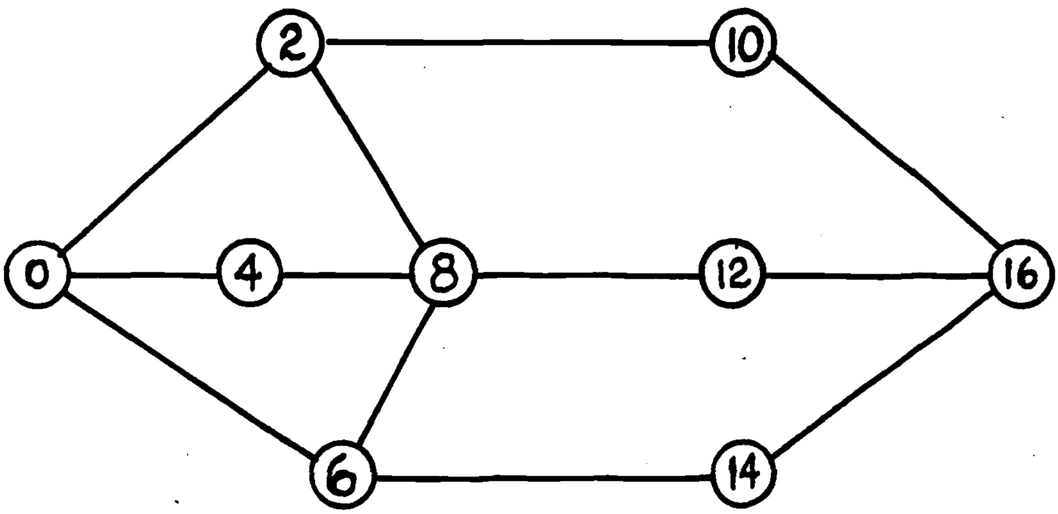


FIGURE 3-2
Event Oriented Network

In the arrow network diagram (Activity Oriented) each arrow is identified by two numbers, one at the tail and the other at the head. These are usually called the i - j numbers. (See Figure 3-3) In the "circles joined by lines" network (Event Oriented System) each event is identified by a single number. (See Figure 3-4) The geometric shape of a network will be determined by relationships between tasks. They all have one thing in common, and that is, each must close at a final point thus closing a circuit. When the network is completed, it will give much information on the project. In the two systems there are some basic differences which will be explained in the following two paragraphs.

FIGURE 3-3

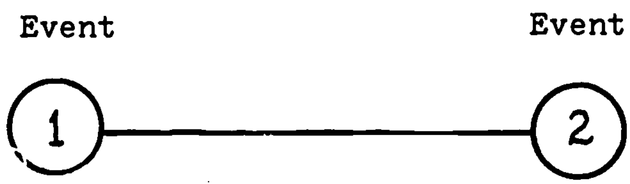


FIGURE 3-4

Let us take the Activity Oriented system with its network formed by arrows, and see what such a network portrays. Arrows succeeding one another mean that activities represented by each arrow in the series cannot begin until each preceding activity is completed. (See Figure 3-5) Arrows beginning at a common point indicate that the activities they represent can begin and run concurrently. (See Figure 3-6) Arrows, meeting at a common point, show that all activities represented by them must be completed before any activity following them may begin (See Figure 3-7). The way in which arrows restrain one another forms the logic of the diagram. When this normal use of arrows confuses, or places restrictions on activities that need not be restrained, correction of the logic of the network is effected by the use of "Dummy Arrows". Such arrows are drawn in dotted lines (See Figure 3-8). When arrows representing different activities begin and end at common points, numbering difficulties arise which must be corrected by numbering "Dummies". These "Dummies" are shown also as dotted line arrows. (See Figure 3-9)

FIGURE 3-5

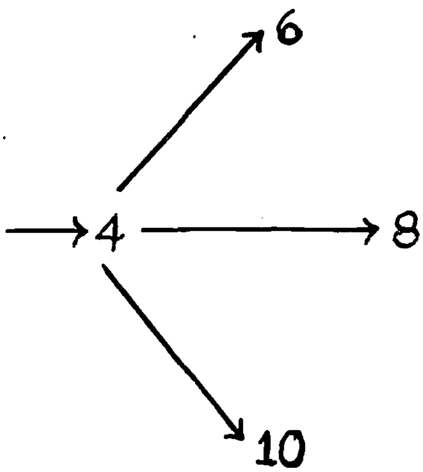


FIGURE 3-6

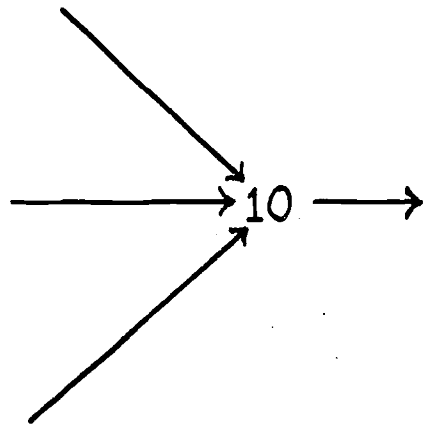
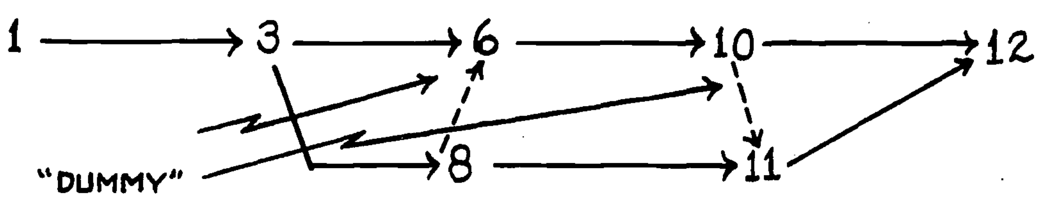
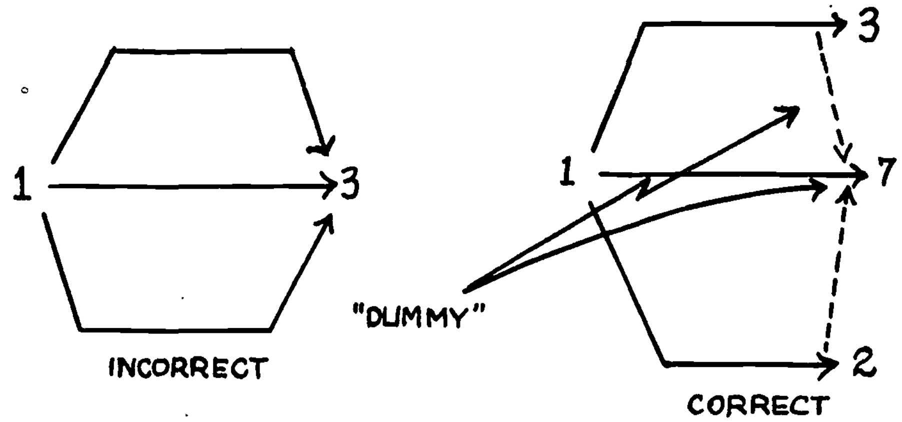


FIGURE 3-7



Activity 3-6 and 3-8 can begin concurrently but 6-10 cannot begin until both 3-6 and 3-8 are finished. Also, activity 6-10 as well as activity 8-11 must be finished before activity 11-12 begins.

FIGURE 3-8



When two or more activities originate and end at common points, it is necessary to introduce a number "dummy" to avoid numbering difficulties.

FIGURE 3-9

The value of each arrow within a network is determined by the usual estimating procedures, assuming the use of the normal team of men and/or equipment that would accomplish the job efficiently and economically. Each arrow is valued at the duration estimated for that specific activity. "Dummies" have zero value at all times. The junctions where arrows meet are called "Nodes" and correspond to the event points in the Event Oriented network.

In the Event Oriented network each event is given a point in time value. The duration allowed for activities is determined by the difference in values between two points. Normally the use of dummy lines is not necessary in the Event Oriented System.

So much for the differences between the two systems. An understanding of both systems is inherent in the knowledge of either one. Further reference to the Event Oriented system will be made only when it might help to clear a point.

The network in its final form will identify activities, their durations and relationships. Such information in graphic form enables the planner to determine:

1. The expected project duration.
2. The tasks that are critical.
3. The points in time relationships when tasks can begin and finish.

4. The time points at which they must begin and finish so as not to interfer with the overall duration of the project.

5. The tasks that must be expedited if it is desired to reduce the project duration.

6. The leeway available for scheduling individual tasks.

Extraction of all the pertinent data from the network is a simple arithmetical process. Data is shown in a tabulated schedule (Figure 3-10) and may be transferred to a bar graph with a confidence never possible in the old system of scheduling. Of course as the complexity and magnitude of a project increases, the arithmetical development of the system must be augmented by the use of computers; however, in the current state of the art the network sequence and relationship planning must be done manually.

I - J	Duration	Description of Task	ES	EF	LS	LF	FLOAT*
0 - 2	5	Layout & Excav	0	5	0	5	0
2 - 4	4	Install Buried Pipes	5	9	5	9	0
2 - 18	10	Foundation Walls & Concrete Floors	5	15	41	51	36
2 - 20	16	Pave Service Road	5	21	50	66	45

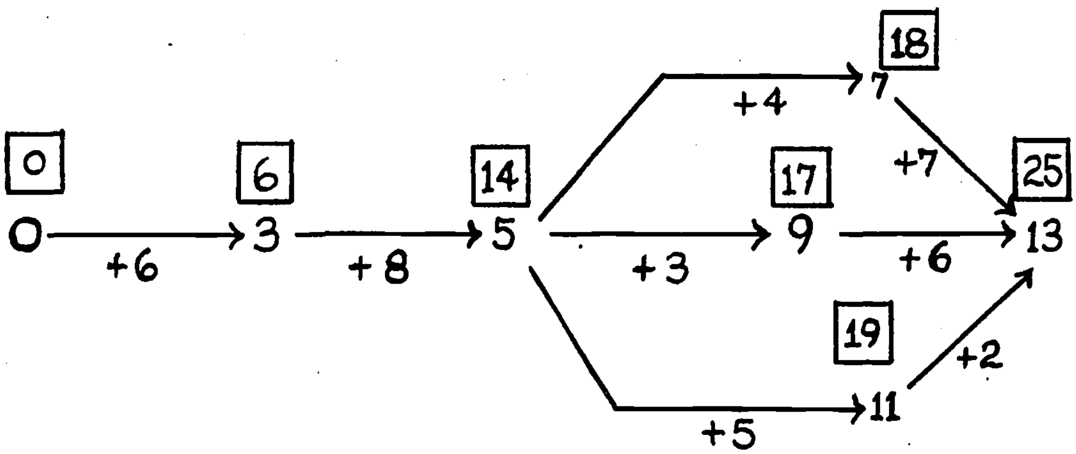
FIGURE 3-10

*Float is the difference between earliest and latest finish time. This represents leeway the project manager has in scheduling a task in order to get it done without increasing the project duration. Zero float appears on those tasks which make up the critical path.

Determining the Project Duration and the Critical Path.

1. The first step in analyzing the network is to make a determination of the project duration. Each event is examined to determine its earliest finish time. This is accomplished by adding the duration of each activity to the earliest finish time of the activity immediately preceding it, e.g., starting at zero time, trace through the network the activity arrow into the next event. The duration of this activity added to zero is the earliest finish time for the event immediately following. Trace the succeeding activity of this event to the next event. Add its duration to the preceding event's earliest finish time to obtain the

next event's earliest finish time. When more than one activity arrow terminates in an event, the activity of longest duration determines the earliest finish time for the event (See Figure 3-11). The value of the longest continuous path through the network is the duration time for the project. All activities in this path will be critical.



Number under arrow = Duration

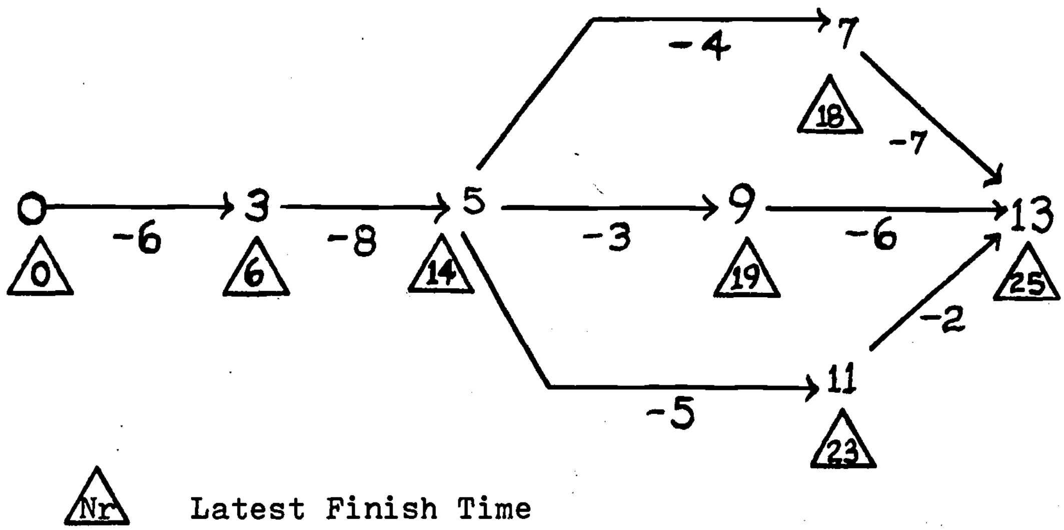
$\boxed{\text{Nr}}$ Earliest Finish Time

To determine duration of project calculate the earliest time for completion of each event. Add activity duration at each event tracing forward. Longest continuous path, in this case 0-3-5-7-13, establishes project duration as 25 time units.

FIGURE 3-11

2. The second step is to find the latest finish time for each event. The latest finish time for the final event of the project is set at same figure as the earliest finish time. Each path, beginning at the completion end of the network, is examined to determine the latest time a preceding event must take place to permit the accomplishment, on time, of the longest succeeding activity. This constitutes the latest finish time for the event. Where the tail

of more than one arrow begins at an event, the duration time of each activity is subtracted from the latest time of the event following it. The lowest answer obtained is the latest time for the event under consideration. There is no problem with single arrows. This is just a matter of subtracting the duration value of that activity from the succeeding event latest finish time. (See Figure 3-12)



Latest Finish Time

To determine latest time for each event, track back from last event. Subtract activity time from succeeding event. Where more than one arrow enters an event use the lowest number obtained.

FIGURE 3-12

3. It should be noted here that the earliest and latest finish times at each event are found primarily to establish duration, and help identify the critical path. In the first two steps it is not necessary to establish all of the earliest start and finish times for all activities.

4. The third step is to identify the Critical Path. Criteria for identifying Critical Path are:

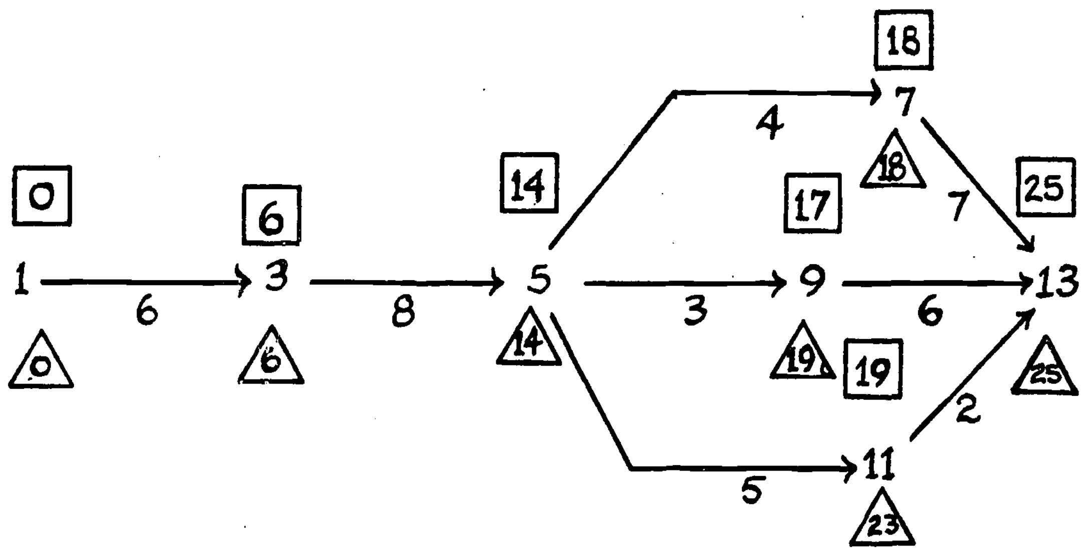
a. Earliest and latest finish times at head of activity arrow are equal.

b. Earliest and latest times at tail of activity arrow are equal.

c. Difference between the earliest and latest times at the head and tail of activity arrow is equal to the duration of the activity. All three of these criteria must be present to establish a Critical Path.

5. The fourth step is to tabulate the information obtained in the preceding steps and determine float. This is accomplished by identifying each activity by its tail to head (i-j) number in numerical sequence (See Figure 3-10).

6. Figure 3-13 is presented as illustrative of the technique of setting up a network and schedule. The planner can show his plan as fine or gross as he may wish for his particular use. What may appear as only an arrow in a higher level plan may be developed into a network at a lower level.



SCHEDULE

Nr. of Activity	Activity	Duration	ES	EF	LS	LF	FLOAT
1 - 3	A	6	0	6	0	6	0
3 - 5	B	8	6	14	6	14	0
5 - 7	C	4	14	18	14	18	0
5 - 9	D	3	14	17	16	19	2
5 - 11	E	5	14	19	18	23	4
7 - 13	F	7	18	25	18	25	0
9 - 13	G	6	17	23	19	25	2
11 - 13	H	2	19	21	23	25	4

FIGURE 3-13

Caution in the Use of the System

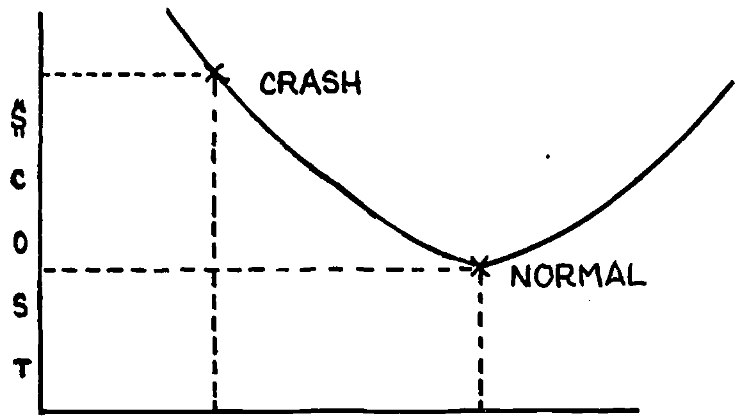
1. Estimating remains the lifes blood of the operation.

2. Estimation using reasonable resources should be the rule when preparing the network. If the project duration is greater than can be tolerated, the network should be searched for the tasks that can be shortened by the application of resources from tasks having float.

3. Limited resources may place restraints that will increase the duration.

An activity or project will normally have a cost function curve that will be somewhat like that shown in Figure 3-14. For every task there is a length of time for accomplishment, which associated with a team of men and equipment using a special method, will result in a least cost for the job. Such a point is represented by the term Normal in Figure 3-14. This point cannot be considered as the least cost alone; because, it may not be sufficient to identify the practicable or required time. For example, let us consider the plastering of a room which will take 80 man hours. It is possible to have two tradesmen working simultaneously with no decrease in efficiency or cost. The duration is 40 hours. It still requires 80 man hours but no additional cost. The normal time for the job is 40 hours; but as we add more men, more equipment or more expensive equipment the time is reduced and the cost rises. On the other hand if an insufficient team is used, time increases as well as cost.

Compression of time of an activity below the normal will cost money. E.g., let us assume a man digging a hole will take forty hours. There is room for only one man to work. If he works eight hours a day he will take five days. Assume he is paid $1.00 per hour, the cost of labor will be 40 dollars. You wish to expedite the job. You can't put more than one man to work at a time; so probably, you will have to pay overtime for an extra shift. Assume $1.50 per hour for an additional man to work the extra shift. The job will be done in 2-1/3 days, but the cost will now be $48. Say this is not satisfactory. You add a third man and finish the job in 1-2/3 days. This is the shortest possible time you can do this job with manpower, and is called the Crash point. The cost now is $52. Any further spending of money will be useless; because, this is the absolute minimum time for this particular method. The Crash position on the curve in Figure 3-14 represents the absolute minimum time.



Time Units

Cost Curve

FIGURE 3-14

The Critical Path network planning method of determining costs makes use of the Normal Cost, the Crash Cost, the Crash Time, and the Normal Time to calculate the cost per unit of time reduction. This last establishes the Cost Curve and is known as the slope of the curve joining the Normal and Crash points.

The slope of the Cost Curve is obtained by dividing the crash cost minus the normal cost, by the normal time minus the crash time. This gives the cost in dollars per unit of time reduction.

$$\frac{\text{Crash Cost - Normal Cost}}{\text{Normal Time - Crash Time}} = \text{Cost per Unit of Time} = \text{Slope}$$

This approach is an oversimplification but for purpose of these notes it is sufficient.

Any task may have the possibility of being reduced in time to accomplish, by increasing the allocation of funds or manpower. The term "Normal" refers to the time costing the lowest in direct cost. The term "Crash" refers to the minimum possible time it takes to accomplish a given task associated with a minimum cost for that minimum time. The network method is used as a tool to identify those tasks which should cost the least to reduce in duration, either individually or in combinations. The parameters of "Crash" and "Normal" times for each task in a given project normally give the planner many alternatives from which to select the task(s) to effect a reduction to least time for least cost. Selection of a given task or tasks for reduction will result in a different schedule and a different duration time for the project. On the other hand, the combination of tasks selected for reduction may have no effect whatever on the total project duration. This may be desirable in some instances, and the manager should be able to identify what he is accomplishing. Certainly this is where the Critical Path Method is of great assistance.

A criterion for choosing a task or tasks for reduction is based on cost.

Let us take a network (See Figure 3-15).

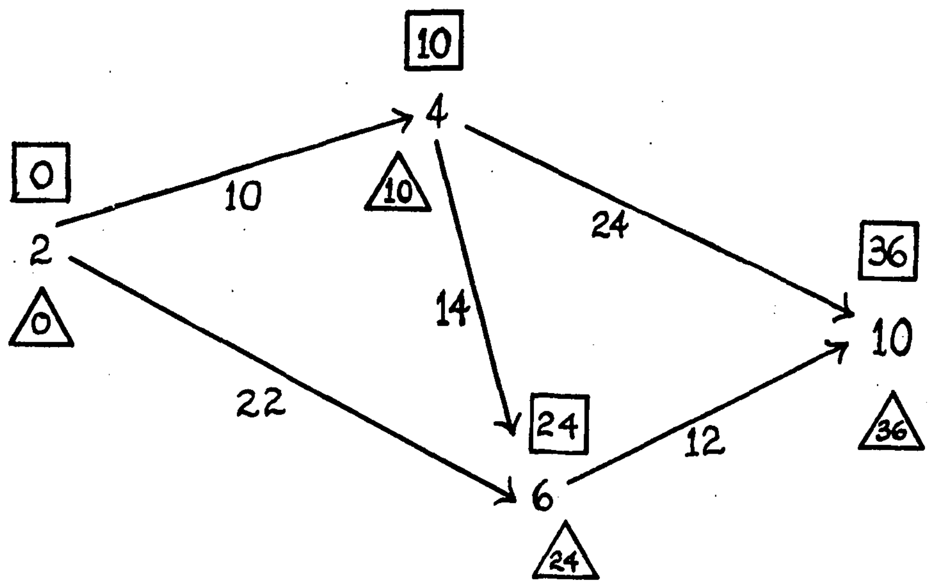


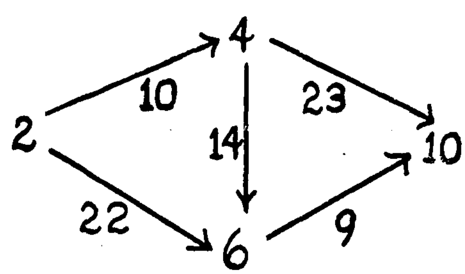
FIGURE 3-15

The project duration amounts to 36 time units. Consider the following information:

Task	Normal Time	Normal Cost	Crash Time	Crash Cost	Slope
2 - 4	10	200	9	300	100
2 - 6	22	240	18	500	65
4 - 6	14	280	13	500	220
4 - 10	24	200	22	250	25
6 - 10	12	680	8	840	40
		$1600		$2390	

Problem #1. You wish to reduce the project duration by one day. Consider first the duration of the project, as it stands now, is determined by the total of all the task durations on the Critical Path. The Critical Path in this network is currently 2 - 4, 4 - 6, 6 - 10. You have a choice of only three tasks which effect the duration of the project. It is easy to see only one job should be reduced, and that is the one costing the least per day of reduction, viz: 6 - 10. We can reduce the project by one day for only forty dollars additional.

Problem #2. Suppose it is desired to reduce the time length of the project by three days. Examination of the network reveals we can reduce one more day in the original Critical Path, but beyond that we will be confronted with two other paths which become critical. In this case all the paths must be examined, and the best combination selected. Paths 2 - 4 can be reduced by only one day, 2 - 6 by 4 days, 4 - 6 by 1 day, 4 - 10 by 2 days, 6 - 10 by 4 days.



Path 2-4-10 must be reduced by one day.

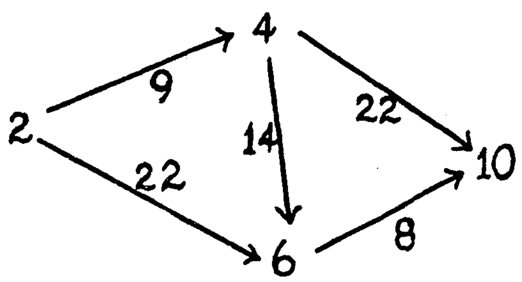
Path 2-4-6-10 must be reduced by three days.

Path 2-6-10 by one day.

Activity	Cost	Duration
2-4	200	10
4-10	225	23
2-6	240	22
4-6	280	14
6-10	800	9
	$1745	

In this situation you didn't have much of a choice; however, if you had, you would select the combination of reductions costing the least in money.

Problem #3. You wish to get the job done in the minimum time possible and at the least cost. The question here is, which path will govern the least time?



Path 2-4-10 governs, therefore, any reduction below 31 days for any of the other paths is a waste of money.

Activity	Cost	Duration	
2-4	300	9	C.C
2-6	240	22	N.C
4-6	280	14	N.C
4-10	250	22	C.C
6-10	840	8	C.C
	$1910		

In the past it has been common practice to crash every thing and thus spend money for no return in time saved. If we had crashed each task in this network we would have spent $480 needlessly. When you have reached the minimum time with the least cost in manpower, and further allocation of such resources return no further reduction in time, it is useless to add more men or machines. However, care must be taken to make this determination based on methods employed.

What has been said about the Critical Path Method is by no means as full an explanation of the system as will enable the reader to begin using the system immediately. It should, however, serve as an orientation on the system and enable the reader to recognize its worth in any type of planning and scheduling conceivable.

The advantages and disadvantages of the Critical Path Method are much the same as the Bar Chart and PERT. The Critical Path is most useful on larger projects.

CHAPTER IV

CONSTRUCTION SITE PREPARATION

The contract usually requires the Contractor to make all necessary temporary utility connections for fuel, power, water and lights, or for whatever utilities are necessary during the construction phase of the project. This requires arrangements with the utility companies for their use and for payment purposes. The Inspector must check these connections to be sure that the meters and measuring devices are properly billed to the Contractor until such time as the permanent connections are made to the construction project at the point in time that the Owner agrees to assume this responsibility.

Construction sites are frequently located in areas adjacent to other buildings and structures. Many times the utility lines serving these facilities are located within or very close to the new project. The Architect/Engineer checks all available data during the design period and locates all known utilities on the drawings. These should be carefully laid out on the site and marked before excavation begins and must be protected during the construction phase. Disruption of these services without written permission of the adjacent property owners could cause costly damage claims and legal actions against the Contractor and Owner of the new construction.

A sketch of the site depicting the areas set aside for construction equipment, vehicle parking, material storage and field offices for Sub-Contractors, Contractor and Inspector should be prepared and agreed upon prior to the start of work. This must be a carefully thought out plan to be certain that there will be no safety hazards, minimum traffic congestion during construction and that adequate space is available to secure, receive, store and issue building supplies and materials.

Safety on and off the site is <u>mandatory</u>. Provisions must be made not only to protect the project and the workers but also the public and adjoining structures. Barricades must be erected and protective measures taken to prevent unauthorized persons from entering the job site and to protect pedestrians from falling debris and operation of construction equipment.

Organization of Architect/Engineer's Representative or Inspector on the Construction Site

The size, magnitude and location of the project determines the requirements for a field office for the Inspector. The composition of an Architect/Engineer's field office should be of sufficient size to provide a table for plans, plan racks, book shelves and file cabinet space to contain the correspondence, shop drawings, etc. This office should be completely separate from the Contractor's field office.

The staff of the Architect/Engineer usually provide their own reference library; therefore, the Inspector should have reference books, necessary work clothing, safety glasses, ear plugs and other items required to properly evaluate the work and enter into the construction areas for inspections.

The Architect/Engineer has available a comprehensive library of technical publications and portable equipment that he provides if the job site is a considerable distance away from his place of business.

A list of references recommended for a field library is as follows:

1. Architectural Graphic Standards (Ramsey, Sleeper)

2. Data Book for Civil Engineers, Design (Seeley)

3. CRSI Design Handbook (Concrete Reinforcing Steel Institute)

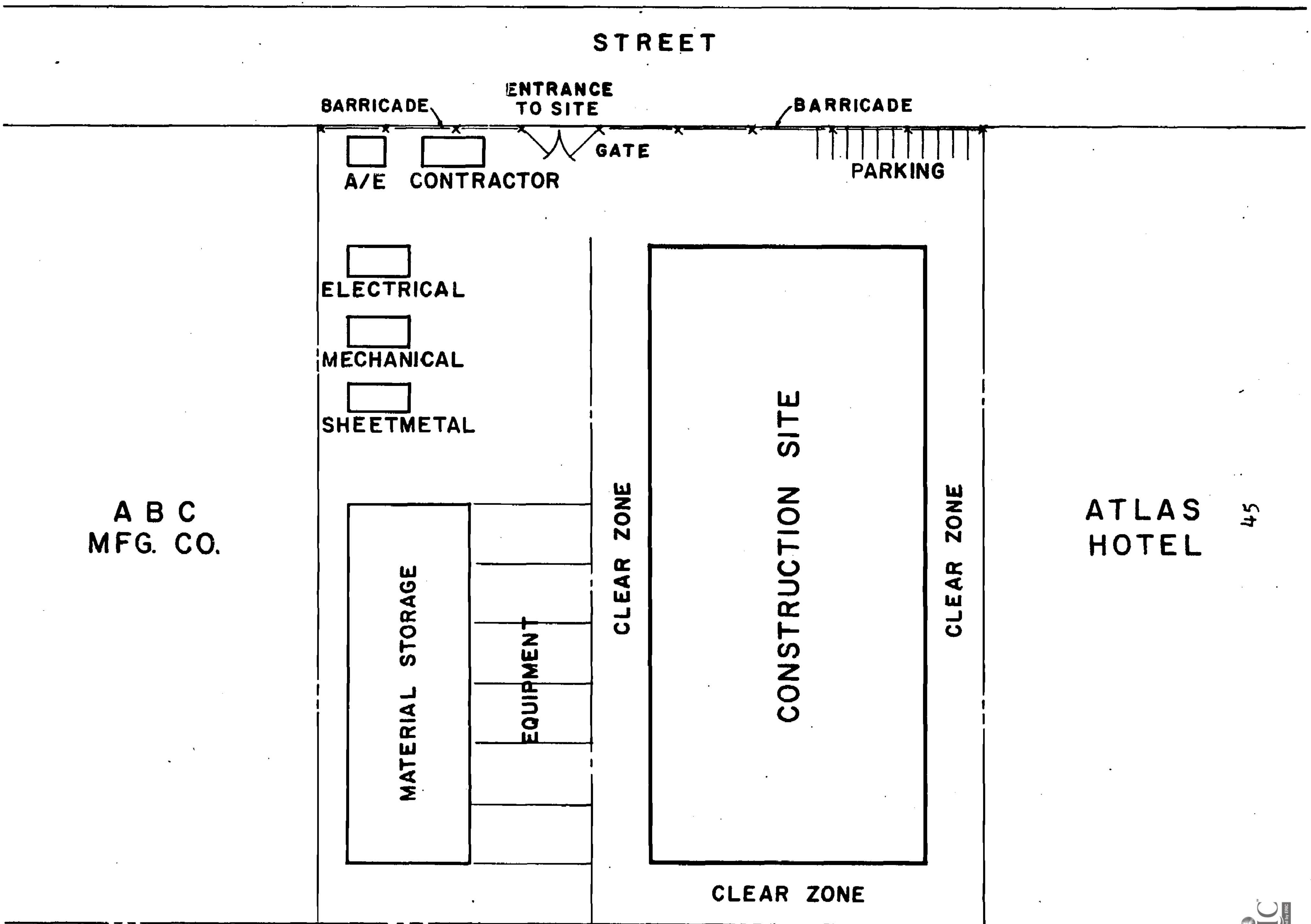
4. Reinforced Concrete Design Handbook (American Concrete Institute)

5. Design and Control of Concrete Mixes (Portland Cement Association)

6. Steel Construction Manual (American Institute of Steel Construction)

7. Modern Timber Engineering (Scofield - O'Brien)

7a. Masonry Design Manual Reinforced Masonry Design Handbook



CONSTRUCTION SITE PLANNING

8. National Design Specifications for Stress - Grade Lumber and Fastenings (National Lumber Manufacturers Association)

9. Brick and Tile Engineering Handbook of Design (Plummer)

10. Underpinning, Practices and Applications (Prentis and White)

11. Mechanical and Electrical Equipment for Buildings (Gay, Devan Fawcett and McGuiness)

12. Heating, Ventilating, Air Conditioning Guide (American Society of Heating and Ventilating Engineers)

13. All applicable building codes and ordinances for the project area.

14. Occupational Safety and Health Standards (Dept of Labor) Law and Explanations Handbook (AIA)

15. Dictionary

Continuous on site inspection is most advantageous to the Contractor, Owner and the Architect/Engineer. Many items can be clarified for the Contractor immediately by the Inspector or within a reasonable time frame by contacting the Architect/Engineer. The Owner is assured that he is obtaining quality workmanship and the Architect/Engineer has the assurance that his plans and specifications are being interpreted correctly.

It is unfortunate that continuous inspection is not always provided. On smaller projects, cost becomes a prime factor in most cases and will not always support the added expense of continuous inspection. Usually projects of one million dollars or more are staffed for continuous inspection. The Architect/Engineer that has several smaller projects under construction will generally try to have an inspector visit the site daily and cover as many areas as time will permit.

Construction records are a very important part of any project. In many cases, the records maintained by the construction inspector are used to settle litigations arising out of disputes between the Contractor and the Owner. It is imperative that information documented by the Inspector be factual, complete and uniformly maintained.

The Daily Diary consists of a bound book (not looseleaf) into which the Inspector enters the date and all pertinent information relating to the project such as discussions with the building Superintendent relating to job conditions, visitors to the site, important discussions with the Architect/Engineer or Owner, problems that arise on the job, solutions agreed upon to problems, and any and all items of interest that may become a matter of importance at a later date. The Daily Diary should be started on the first page and signed by the Inspector after the last entry for the day. The next entry should be dated and started immediately after the last entry so that there are no spaces or lines skipped. In other words, there must be a continuous flow of words. No pages should ever be removed. If there is an error, just mark it out and sign it. The purpose of continuity is so that if the Daily Diary is presented in court as evidence, there can be no doubt in the minds of the legal examiners that anything has been added or deleted from the book at a later date after an incident or a dispute. The Daily Diary should be kept under lock and key for the use of the Inspector only. The information in the Daily Diary is usually reduced to very simple statements and reported to the Architect/Engineer on the Daily Report.

The Daily Report informs the Architect/Engineer of the progress of the work, weather conditions, number of crafts and total number of personnel on the job, Sub-Contractors on the site, meetings, tests, accidents, visitors and a description of the work performed that day. Many Architect/Engineers have their own special forms for Daily Reports. Usually they require the same basic information. (SAMPLE 1)

The Weekly Report is a summation and recapitulation of the week's activities. The Weekly Report is also utilized by the Architect/Engineer to recommend partial payments to the Contractor. (SAMPLE 2)

Photographs should be taken of work progress, controversial items and areas where change orders are being recommended or considered. Most Architect/Engineers encourage photos and will usually provide the Inspector with the necessary camera equipment and film for this purpose. Progress photos should be taken insofar as possible from the same position and location at least once per week on small projects and a minimum of once per month on larger projects.

DAILY LOG OF CONSTRUCTION

	REPORT NUMBER
TO:	DATE
PROJECT	CONTRACT NUMBER
CONTRACTOR *(or hired labor)*	WEATHER

PORTION OF SCHEDULED DAY SUITABLE FOR OPERATIONS					TEMPERATURE	
STRUCTURAL EXCAVATION %	BORROW EXCAVATION %	EMBANKMENT %	CONCRETE %	STRUCTURE %	MINIMUM	MAXIMUM

HAS ANYTHING DEVELOPED ON THE WORK WHICH MIGHT LEAD TO A CHANGE ORDER OR FINDING OF FACT? ☐ NO ☐ YES *(Explain)*	24 HOUR PRECIPITATION	
	INCHES	ENDING M

NUMBER OF GOVERNMENT EMPLOYEES						RIVER STAGE	
SUPERVISORY	OFFICE	LAYOUT	INSPECTION	TOTAL	LABOR	FEET	TIME M

NUMBER OF CONTRACTOR'S EMPLOYEES				NUMBER OF SHIFTS ☐ 1 ☐ 2 ☐ 3					
				FROM M	TO M	FROM M	TO M	FROM M	TO M

WORK PERFORMED TODAY *(Indicate location and description. Where appropriate show number and quantity)*

SAMPLE 1

REMARKS *(Plant, material, visitors, delaying factors, etc.)*

TITLE	SIGNATURE

ENG 1 JUL 62 2538

☆ U.S. GOVERNMENT PRINTING OFFICE : 1962 O—647138

WEEKLY CONTRACT PROGRESS REPORT

CONTRACTOR	DESCRIPTION OF JOB

REPORT NO.	PROJECT NO.	CONTRACT NO.	PERIOD COVERED	COMPLETION DATE REQUIRED	COMPLETION DATE ESTIMATED
		DAAG08-	From: To:		

LINE NO.	WORK ELEMENT	% OF TOTAL JOB	% COMPLETED THIS PERIOD	% COMPLETED CUMULATIVE
	TOTAL →			

REMARKS

S A M P L E 2

PROGRESS OR COMPLETION STATEMENT

The above contractor has satisfactorily completed the indicated percentage of the contract in accordance with the contract specifications, except as noted.

SUBMITTED BY OR FOR:

☐ CONTRACTOR ☐ GOVERNMENT INSPECTOR

TYPED OR PRINTED NAME AND TITLE	SIGNATURE	DATE
GOVERNMENT INSPECTOR		

REVIEWED BY OR FOR CONTRACTING OFFICER

TYPED OR PRINTED NAME AND TITLE	SIGNATURE	DATE
CONTRACT ADMINISTRATOR		

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CHAPTER V

FOOTINGS AND FOUNDATIONS

The success of any type of construction depends upon the ability of the foundation to support it. The finest workmanship, best materials and most exacting compliance with the plans and specifications for a building or structure cannot overcome a faulty or improper foundation design or construction. Although it is not expected that the construction inspector will be called upon to design foundations for buildings and structures, he should know and understand the principals of design that the Architect or Engineer used to determine the requirements for construction. In many cases the Inspector on the site can recognize conditions that may not have been apparent or unknown conditions that develop during the excavation procedures.

Soil Bearing. The natural formation of the earth being the ultimate material that all construction must rest upon, dictates that extreme care must be exercised to determine its strength and ability to support a given load. Where unsuitable material is encountered on or below the surface of the site, it can in some instances be removed, combined with other materials to strengthen it, or replaced in its entirety with imported materials. In some cases it may be necessary to penetrate the soil great distances to rest upon a suitable soil material by utilizing piling or caissons.

Soils have been classified for identification purposes. A Soils' Engineer should be consulted and laboratory test conducted on soils prior to design, including soil borings and classification of the strata.

Preliminary investigation of a construction site is conducted by the Architect or Engineer prior to design of a building or structure. The most commonly used data readily available are topographic or aerial maps, geologic survey maps, case history of original site development, review of foundations used for adjacent buildings and the results from standard penetration tests. He usually requires one penetration to 25 ft depth and one to hard strata.

Final investigation after the building is site adapted on a plot plan usually requires a penetration boring or core taken at each corner of the building by referencing all holes to a known benchmark location. The ground water level, the PH and the electroresistivity of the soil are determined. Undisturbed soil samples are taken and laboratory results evaluated. Based upon the results of a complete soils analysis, the

Architect or Engineer can design a foundation structure to satisfy the existing conditions of the earth strata. Considerations must also be given to depth of frost penetration, drainage, snow, wind and earthquake influences in areas subjected to these elements.

ABORATORY TESTS TO BE PERFORMED FOR VARYING TYPES OF SOILS

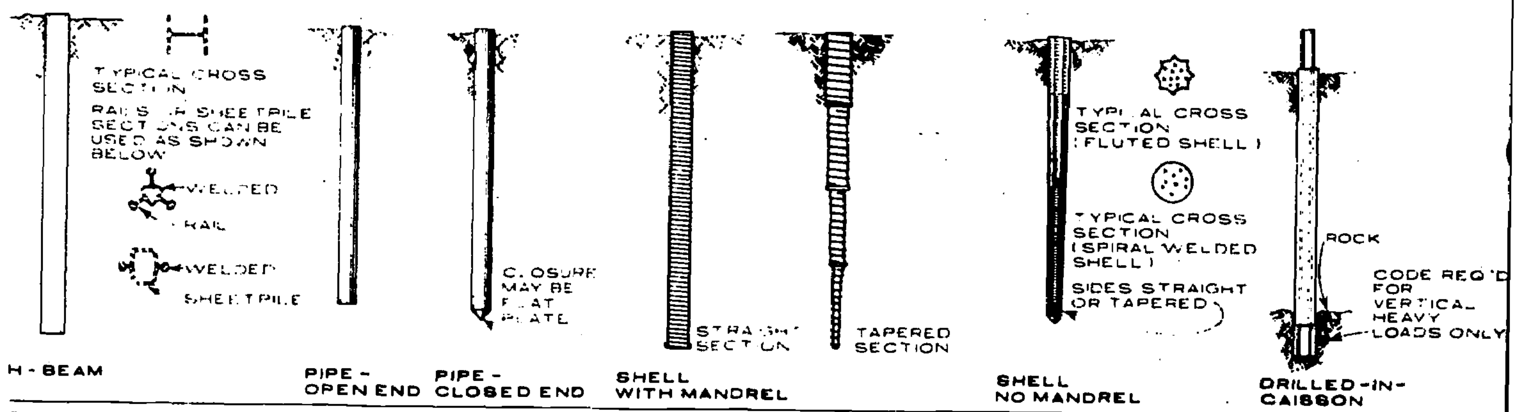
	SANDS & SILTS	SANDY CLAYS	CLAYS
RY DENSITY	YES	YES	YES
IOISTURE CONTENT	YES	YES	YES
TTERBERG LIMITS	NO	YES	YES
ERMEABILTY	YES	YES	NO
IECHANICAL ANALYSIS	YES	YES	YES
ONSOLIDATION	NO	YES	YES
INCONFINED COMPRESSION	NO	YES	YES
IRECT SHEAR	YES	NO	NO
RIAXIAL	YES	YES	YES
ANE SHEAR	NO	NO	YES
ELATIVE DENSITY	YES	NO	NO

OIL TYPES & VARIOUS PROPERTIES OF EACH

DIVISION	SYMBOLS			SOIL DESCRIPTION	VALUE AS A FOUNDATION MATERIAL	FROST ACTION	DRAINAGE
	LETTER	HATCHING	COLOR				
RAVEL ND RAVELLY OILS	GW		Red	Well graded Gravel, or Gravel-Sand mixture, little or no Fines	Excellent	None	Excellent
	GP		Red	Poorly graded Gravel, or Gravel-Sand mixtures, little or no Fines	Good	None	Excellent
	GM		Yellow	Silty Gravels, Gravel-Sand-Silt mixtures	Good	Slight	Poor
	GC		Yellow	Clayey-Gravels, Gravel Clay Sand Mixtures	Good	Slight	Poor
AND ND ANDY OILS	SW		Red	Well graded Sands, or Gravelly Sands, little or no Fines	Good	None	Excellent
	SP		Red	Poorly Graded Sands, or Gravelly Sands, little or no Fines	Fair	None	Excellent
	SM		Yellow	Silty Sands, Sand-Silt mixtures	Fair	Slight	Fair
	SC		Yellow	Clayey Sands, Sand-Clay mixtures	Fair	Medium	Poor
ILTS ND LAYS L < 50	ML		Green	Inorganic Silts & Very Fine Sands, Rock Flour, Silty or Clayey Fine Sands, or Clayey Silts with slight plasticity	Fair	Very High	Poor
	CL		Green	Inorganic Silts of low to medium plasticity, Gravelly Sands, Silty Clays, Lean Clays	Fair	Very High	Impervious
	DL		Green	Organic Silt Clays of low plasticity	Poor	High	Impervious
ILTS ND LAYS L > 50	MH		Blue	Inorganic Silts, Micaceous or DiatomaceousFine Sandy or SiltySoils, Elastic Silts	Poor	Very High	Poor
	CH		Blue	Inorganic Clays of high plasticity, Fat Clays	Very Poor	Medium	Impervious
	OH		Blue	Organic Clays of medium to high plasticity, Organic Silts	Very Poor	Medium	Impervious
IGHLY RGAN- SOILS	Pt		Orange	Peat & Other Highly Organic Soils	Not Suitable	Slight	Poor

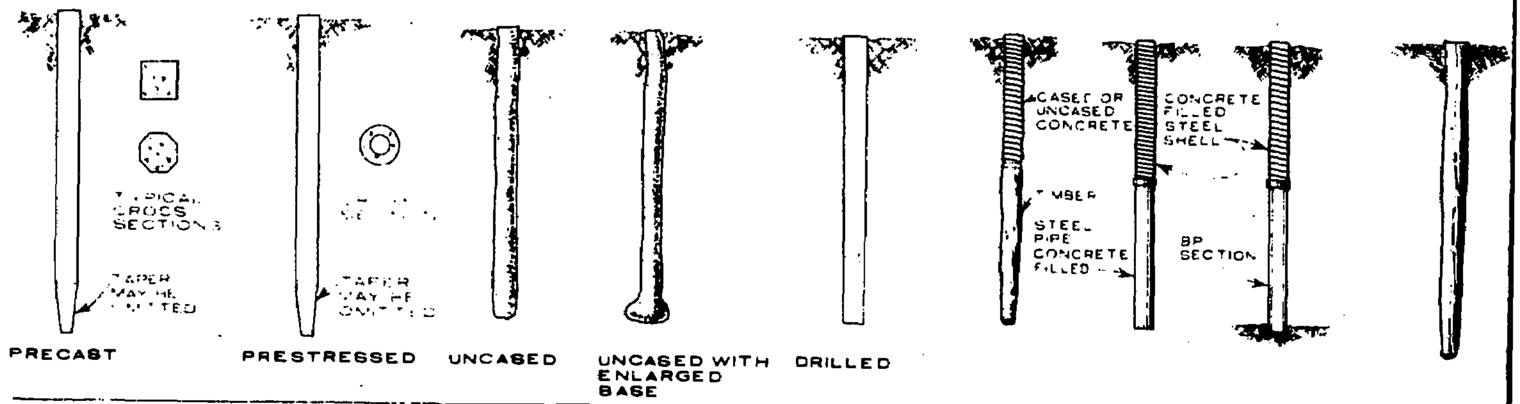
Consult soil engineers and local building codes for allowable soil bearing capacities.

L. L. indicates liquid limit.



STEEL

NOTE: A mandrel is a member inserted into a hollow pile to reinforce the pile shell while it is driven into the ground



CONCRETE

COMPOSITE

TIMBER

PILE DATA

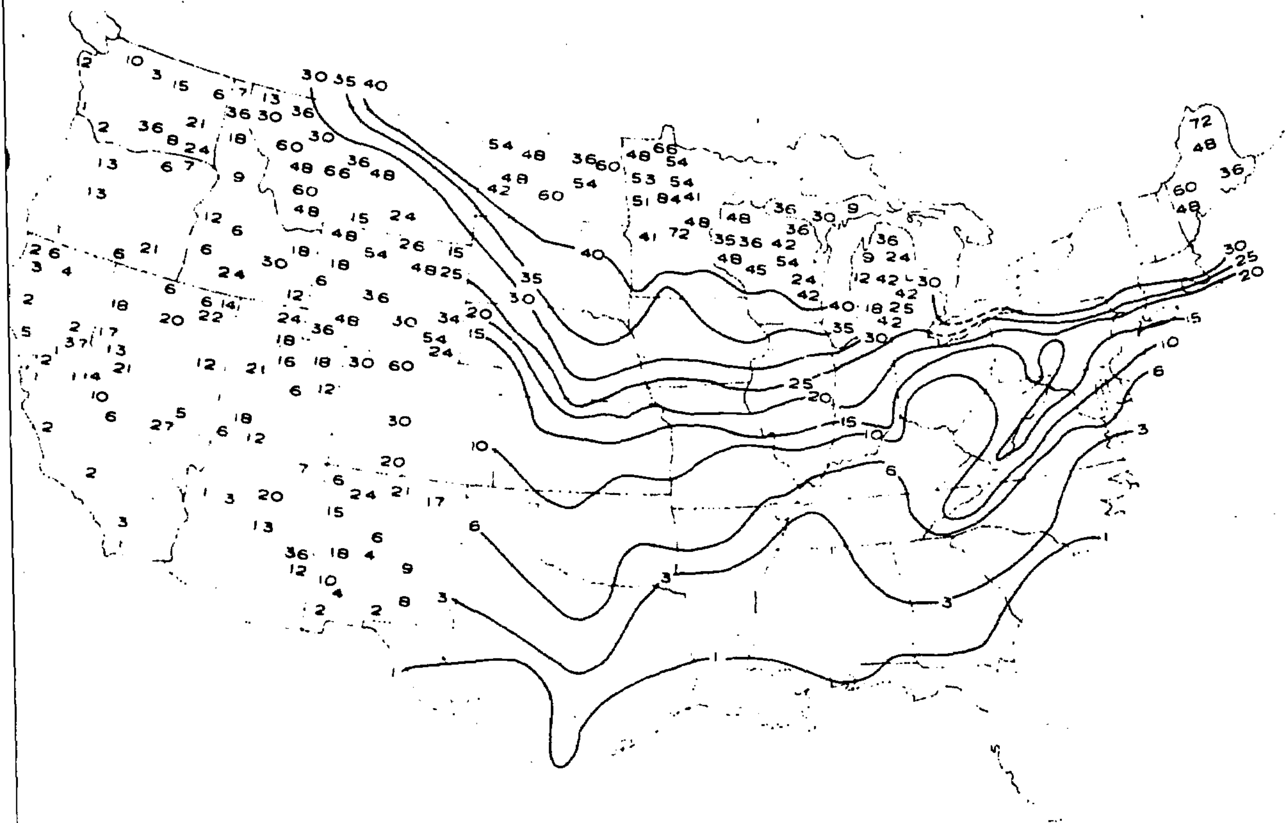
PILE TYPE	MAXIMUM LENGTH (FT)	OPTIMUM LENGTH (FT)	DIAMETER (IN)	MAXIMUM LOAD CAPACITY (TONS)	OPTIMUM LOAD RANGE (TONS)	USUAL SPACING
TIMBER *	110	30 60	5 – 10 Tip; 12 – 20 Butt	30	15 – 25	2' – 6" to 3' – 0"
STEEL						
H-BEAM	200	40 – 100		200	40 – 120	3' – 0"
PIPE - OPEN END CONCRETE FILLED	200	40 – 120	10 – 22	200	80 – 120	2' – 6" to 3' – 6"
PIPE - CLOSED END CONCRETE FILLED	150	30 – 80	10 – 18	100	50 – 70	2' – 6" to 3' – 0"
SHELL - MANDREL CONCRETE FILLED						
STRAIGHT SECTIONS	100	40 - 60	8 - 18	75	30 – 60	3' – 0"
TAPERED SECTIONS	40	15 - 35	8 23	60	30 - 45	3' 0"
SHELL - NO MANDREL CONCRETE FILLED	150	30 – 80	8 – 18	80	50 - 70	3' - 0"
DRILLED - IN - CAISSON	200	50 – 120	24, 30	2 000	500 - 1 500	6' – 0"
CONCRETE						
PRECAST	100	40 - 50	10 – 24	100	40 - 60	3' – 0"
PRESTRESSED	200	60 – 100	10 - 54	200	50 - 150	3' - 0" to 8' - 0"
UNCASED	60	25 - 40	14 - 20	75	30 60	3' - 0"
UNCASED - ENLARGED BASE	60	25 – 40	14 20	150	40 – 100	6' 0"
DRILLED (CAISSONS)	200	40 – 100	16 – 84	500	60 - 200	4' - 0" to 10' - 0"
COMPOSITE						
CONCRETE - TIMBER	150	60 100	5 - 10 Tip, 12 - 20 Butt	30	15 - 25	2' - 6" to 3' - 0"
CONCRETE - PIPE	180	60 - 120	10 - 23	150	30 - 80	3' - 0"
CONCRETE - H-BEAM	180	60 120	10 23	150	30 - 80	3' 0"

NOTE:

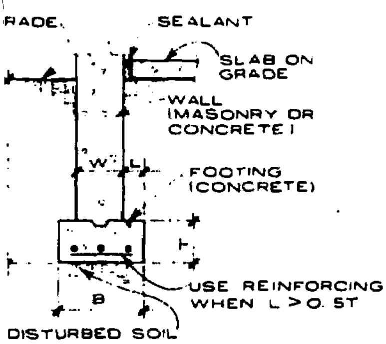
* Timber pile must be treated with wood preservative when any portion is above permanent ground water table

Applicable Material Specifications - Concrete ACL 318, Timber ASTM D25, Pipe ASTM A252, Structural Sections ASTM A36

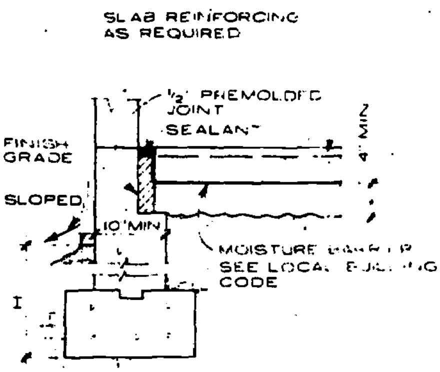
S. V. DeSimone, Munser, Rutledge, Wentworth & Johnston New York, New York



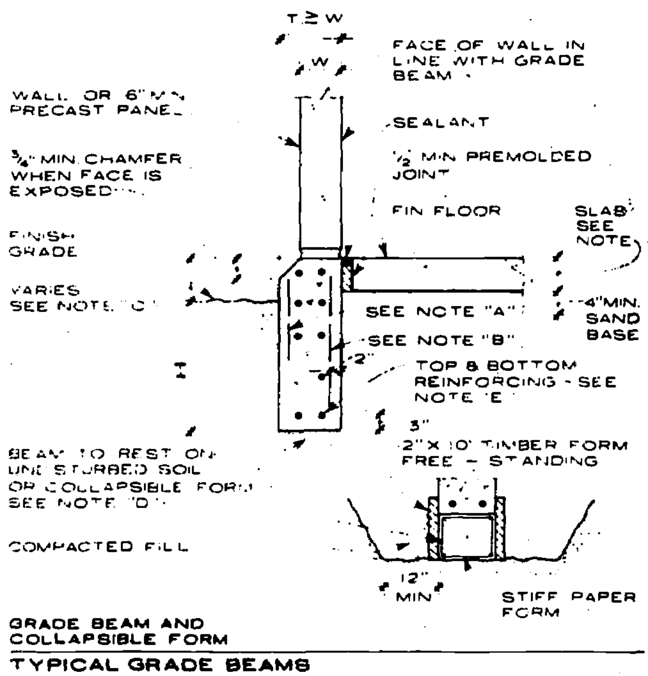
...ERAGE DEPTH OF FROST PENETRATION – H INCHES



...LL FOOTINGS



PERIMETER WALL



GRADE BEAM AND COLLAPSIBLE FORM

TYPICAL GRADE BEAMS

NOTES

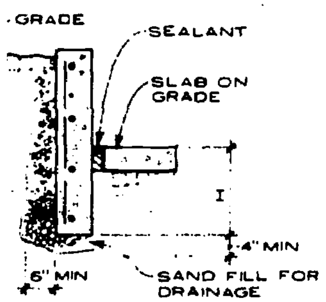
A. Use temperature reinforcing only when face of grade beam is exposed over 18" to weather.

B. Use main reinforcing only when finish grade is below 24" and/or finish floor surcharge load so dictates.

C. When finish grade is below finish floor, design grade beam for vertical and horizontal forces.

D. Use collapsible form when soil under beam is expansive or fat clay (CH). This provides a void which allows for periodic heaving of the soil due to increased moisture content, without lifting the grade beam.

E. Use top & bottom reinforcing for all grade beams.

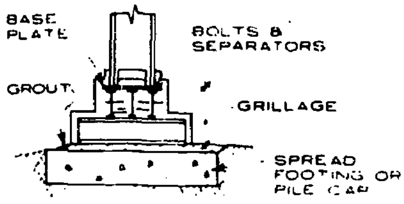


...A WALLS

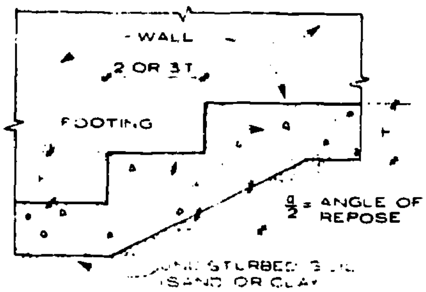
GENERAL NOTES.

1. Adjoining ground to slope away from foundation in all directions and underlying soil to be preferably sand or gravel to reduce to a minimum heaving due to frost action.

2. It is good practice for foundations to extend 12" below frost line; consult local codes.

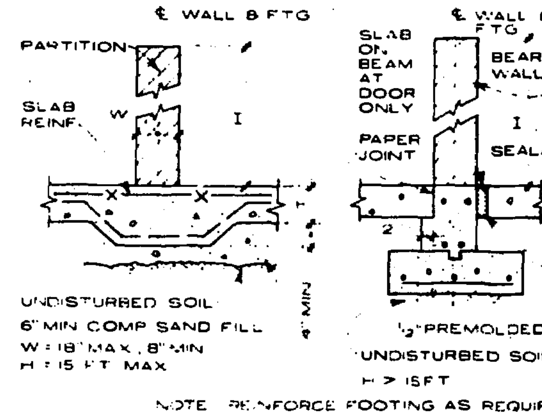


STEEL GRILLAGE FOUNDATION

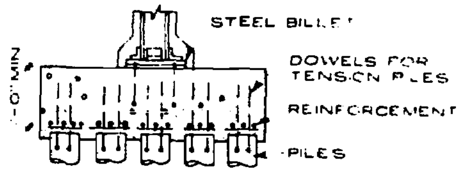


STEPPING OF CONTINUOUS FOOTINGS

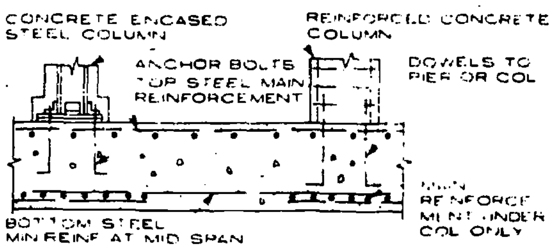
max. steepness 2 horizontal to 1 vertical, or 1/2 angle of repose of supporting soil.



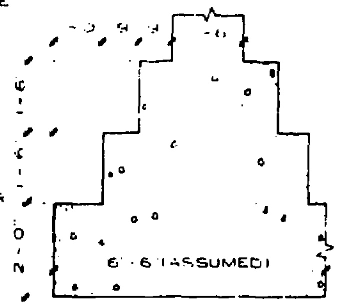
PARTITION AND INTERIOR BEARING WALL FOOTINGS



PILE FOUNDATION

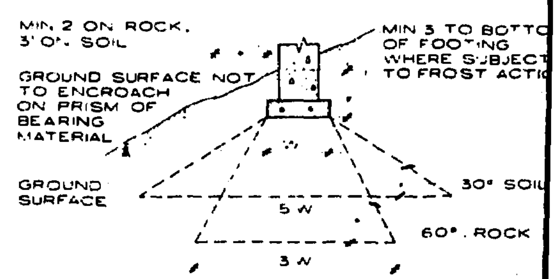


COMBINED FOUNDATION

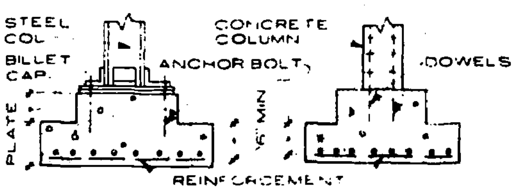


MASS CONCRETE FOOTING FOR HEAVY WALL OR CHIMNEY

depth of steps to be twice their projection

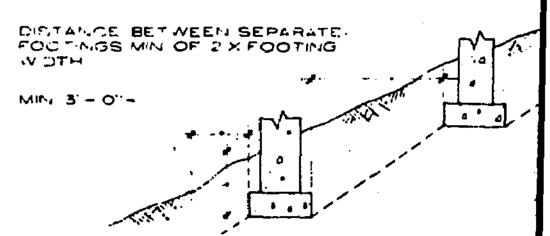


FOOTINGS IN OR ADJACENT TO SLOPING GROUND



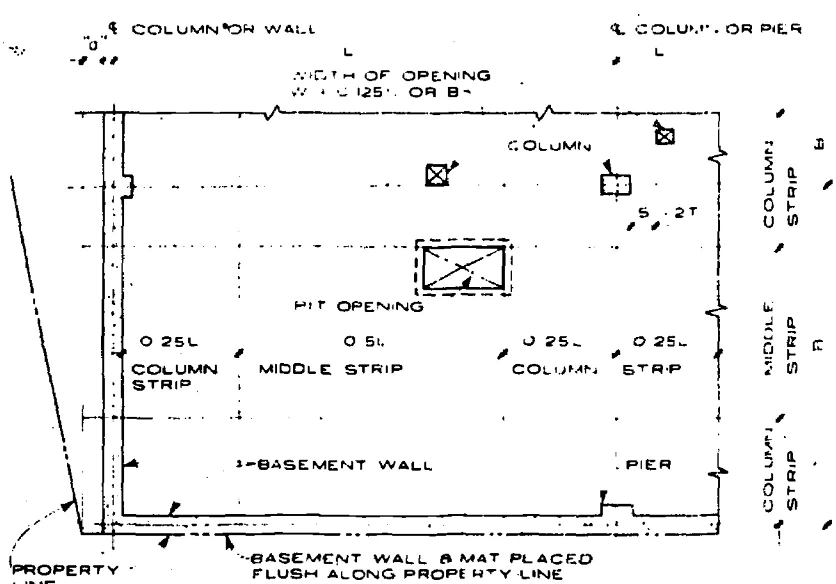
STEEL COLUMN **REINFORCED CONC**

COLUMNS ON SPREAD FOOTINGS



STEPPING OF ADJACENT FOOTINGS

max steepness 1:2 horizontal to 1 vertical, or 3/4" angle of repose of supporting soil.

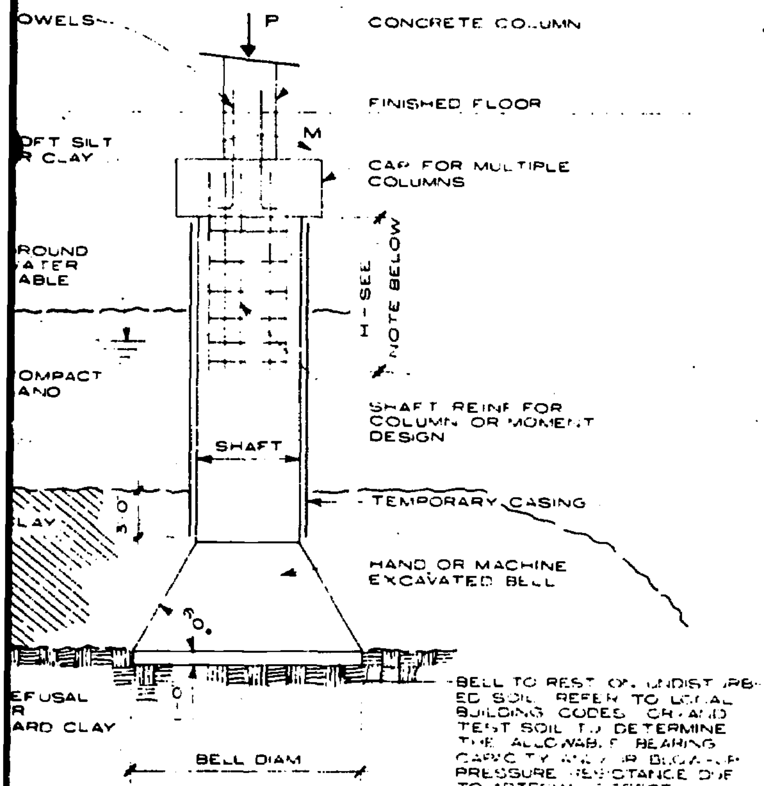


MAT FOUNDATION

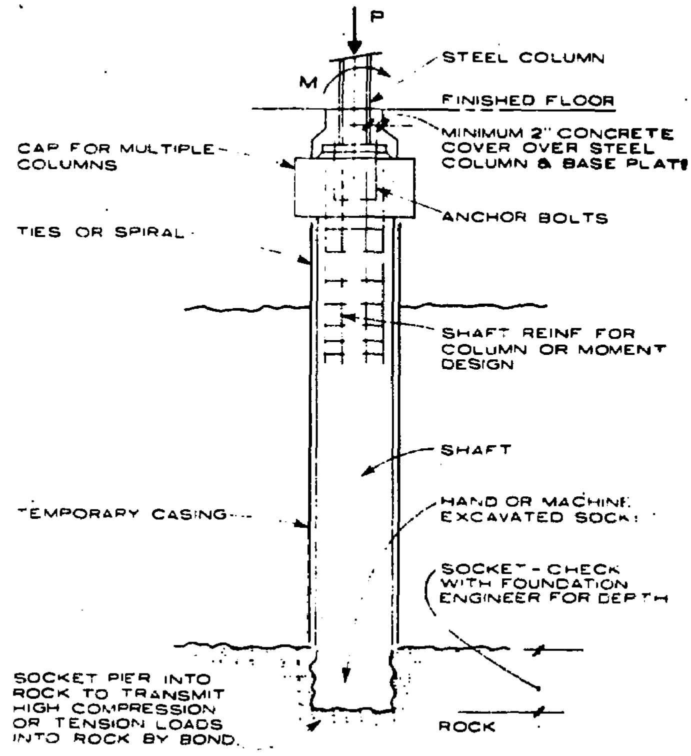
NOTES FOR MAT FOUNDATIONS

1. Column spacing should be L < 1.33 B max
2. Place pit (if necessary) at middle strip.
3. Adjust distance "a" to get an even pressure under mat within the allowable soil pressure
4. Provide membrane waterproofing under mat when mat is less than 12" thick and the ground water level is above the mat
5. Provide water stops in mat and in walls at construction joints.
6. Mat thickness, t = 0.0278 L inches max.

Smith, Hinchman & Grylls Associates, Inc., Detroit, Michigan



ELL FOUNDATION



SOCKET FOUNDATION

EEP FOUNDATIONS; DRILLED-IN-PIERS

OTE

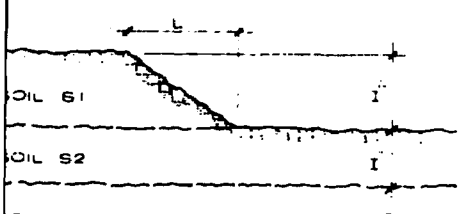
Use temporary casing to seal-off inflow of water or sand into excavation. Delete casing when shaft is in stiff clay.

Grout bottom of shaft against artesian water or sulphur gas intrusion into the excavation.

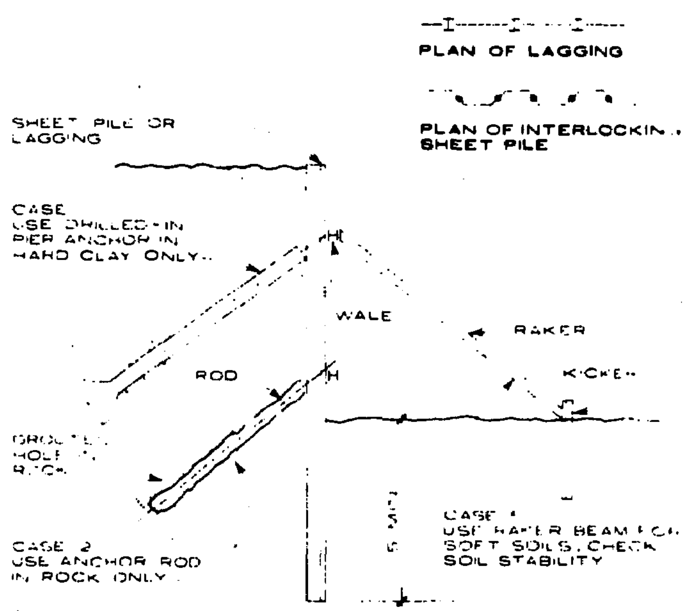
Determine max. bearing capacity of pier by the unconfined compression strength of the soil, and verify it by load tests

H is a function of the passive resistance of the soil, generated by the moment applied to the caisson cap.

Caissons may be used under grade beams or concrete walls.



PEN EXCAVATION



BRACED EXCAVATION

MBANKMENT STABILITY (CONSULT FOUNDATION ENGINEER)

OTE:

When ground water level is above H_1 use well point prior to excavating and as long as the hole is kept open if the soils below excavation level are permeable.

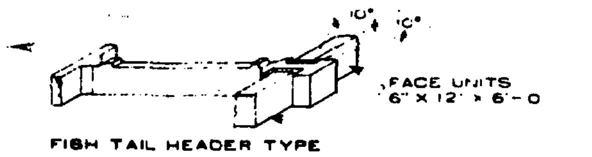
SOIL TYPES			L/H_o	REMARKS
S1	S2	S3		
Fill	Rock		>1.5	Check Sliding of S1
. Clay	H. Clay	Rock	>1.0	Check Sliding of S1
and	S. Clay	H. Clay	>1.5	Check Lateral Displace. of S2
and	Sand	H. Clay	>1.5	
I. Clay	S. Clay	Sand	<1.0	Check Lateral Displace. of S2

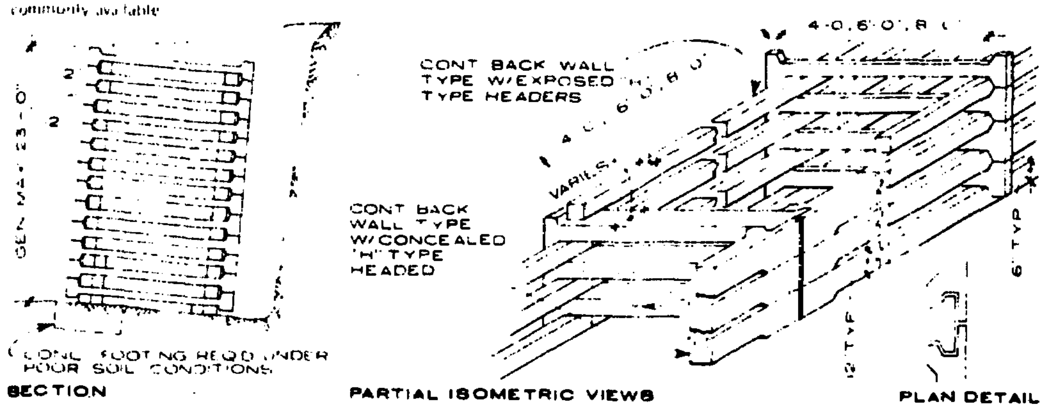
S = SOFT, H = HARD

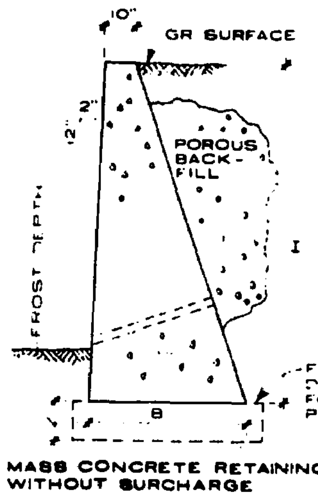
mith, Grylls Associates, Inc., Detroit, Michigan

CONCRETE CRIB RETAINING WALLS

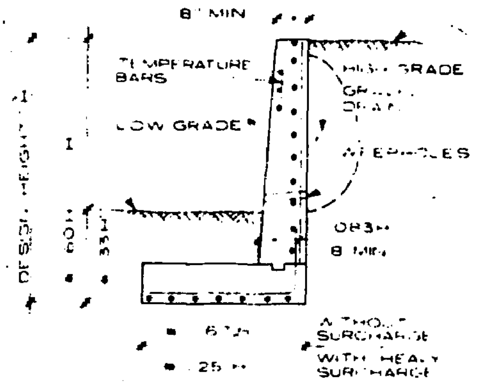
Continuous back wall anchorage types may be erected with a long radius and fishtail types with a short radius. Adverse soil conditions require wall to have extra sill units or foundation. Preliminary wall proportions 6'-0" high x 4'-0" deep; 11'-6" high x 6'-0" deep. Walls up to 6'-0" high may be erected plumb. Continuous back wall anchorage type with exposed "H" type headers is most commonly available.



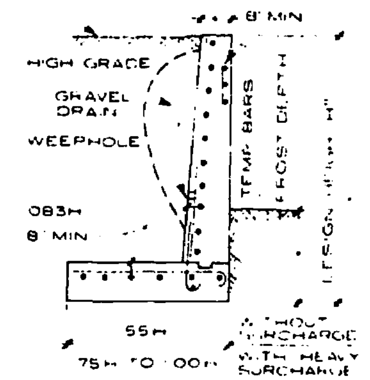




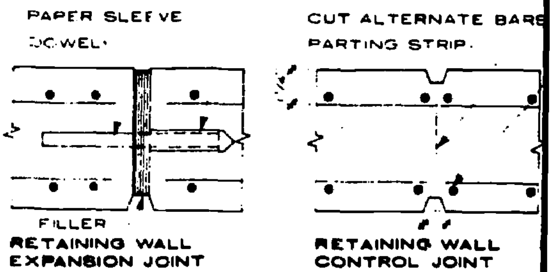
H	B
3'-0"	1'-6
4'-0"	2'-
5'-0"	2'-6
6'-0"	3'-
7'-0"	3'-
8'-0"	4'-
9'-0"	4'-6
10'-0"	5'-



*Passive earth pressure is developed at lower grade to reduce heel tension to zero and to resist sliding and overturning, therefore low grade must be protected. Place base below frost. Dimensions are preliminary.

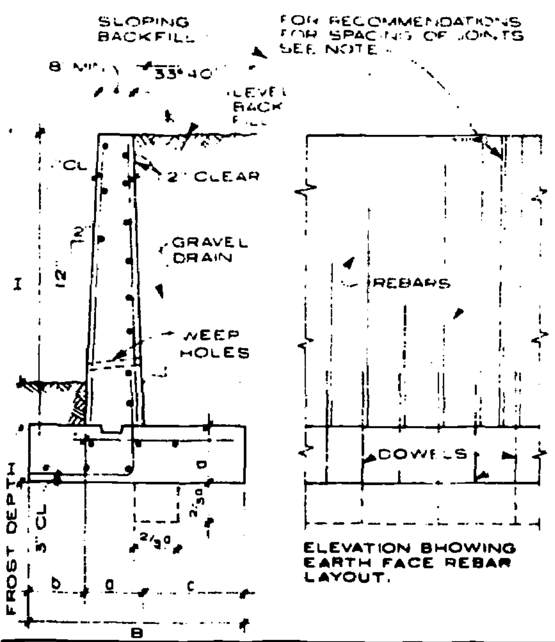


Soil pressure is for equals 2 tons per square foot. Dimensions are preliminary only.



Provide control or contraction joints in concrete retaining walls about every 25 feet and keyed expansion joints about every fourth control joint.
Dowels: 1" x 2'-0" plain bars @ 12" O.C.
Filler: Premolded joint filler.
Parting strip: 16 ga. galvanized sheet steel coated to prevent bond, wire tied to rebars @ 12" O.C.

CONCRETE OUTLINES FOR "L" TYPE RETAINING WALLS



BACKFILL SLOPING Φ = 33°-40'

CONCRETE OUTLINES

HEIGHT OF WALL = h (ft)	B (ft)	a (ft)	b (ft)	c (ft)	*BASE PRESS. AT TOE (psf)
3	2'-6"	0'-11"	0'-7"	1'-0"	1,072
4	3'-2"	1'-0"	0'-9"	1'-5"	1,421
5	3'-10"	1'-1"	1'-0"	1'-9"	1,699
6	4'-6"	1'-2"	1'-3"	2'-1"	1,990
7	5'-3"	1'-3"	1'-6"	2'-6"	2,238
8	5'-11"	1'-4"	1'-9"	2'-10"	2,512
9	6'-8"	1'-5"	2'-0"	3'-3"	2,753
10	7'-5"	1'-6"	2'-3"	3'-8"	3,018
11	8'-1"	1'-7"	2'-6"	4'-0"	3,298
12	8'-10"	1'-8"	2'-9"	4'-5"	3,536
13	9'-6"	1'-9"	3'-0"	4'-9"	3,805
14	10'-3"	1'-10"	3'-3"	5'-2"	4,058
15	11'-0"	1'-11"	3'-6"	5'-7"	4,310
16	11'-10"	2'-0"	3'-10"	6'-0"	4,477
17	12'-7"	2'-1"	4'-1"	6'-5"	4,719
18	13'-4"	2'-2"	4'-4"	6'-10"	4,959
19	14'-2"	2'-3"	4'-8"	7'-3"	5,104
20	15'-0"	2'-4"	5'-0"	7'-8"	5,300

BACKFILL LEVEL-NO SURCHARGE

CONCRETE OUTLINES

HEIGHT OF WALL = h (ft)	B (ft)	a (ft)	b (ft)	c (ft)	*BASE PRESS. AT TOE (psf)
3	1'-9"	0'-10½"	0'-4"	0'-6½"	885
4	2'-2"	0'-11"	0'-5"	0'-10"	1,136
5	2'-8"	0'-11"	0'-5"	1'-4"	1,361
6	3'-3"	1'-0"	0'-8"	1'-7"	1,415
7	3'-10"	1'-0"	1'-0"	1'-10"	1,398
8	4'-3"	1'-1"	1'-1"	2'-1"	1,643
9	4'-9"	1'-1"	1'-1"	2'-7"	1,851
10	5'-4"	1'-2"	1'-4"	2'-10"	1,944
11	5'-10"	1'-2"	1'-6"	3'-2"	2,051
12	6'-6"	1'-3"	1'-8"	3'-7"	2,129
13	7'-0"	1'-4"	1'-8"	4'-0"	2,403
14	7'-8"	1'-4"	2'-1"	4'-3"	2,332
15	8'-1"	1'-5"	2'-1"	4'-7"	2,608
16	8'-6"	1'-5"	2'-2"	4'-11"	2,799
17	9'-0"	1'-6"	2'-3"	5'-3"	3,008
18	9'-6"	1'-7"	2'-4"	5'-7"	3,207
19	10'-2"	1'-7"	2'-6"	6'-1"	3,264
20	10'-5"	1'-8"	2'-6"	6'-3"	3,119

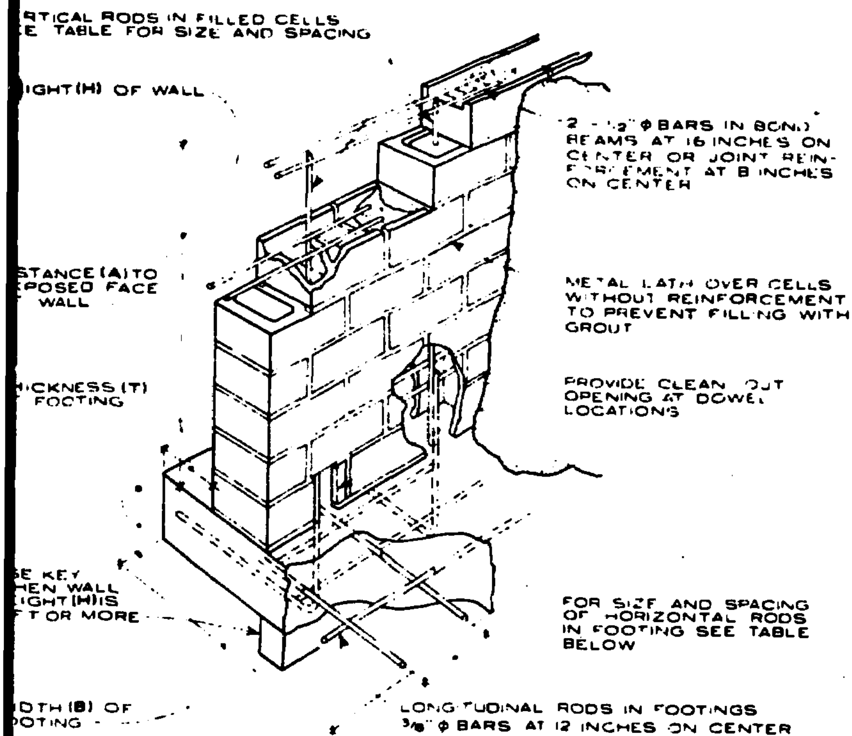
Lug shown dashed may be required to prevent sliding in high walls & those on moist clay

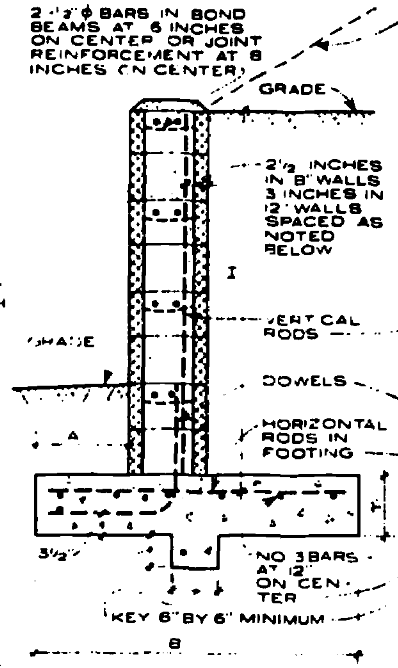
CONCRETE OUTLINES FOR "T" TYPE RETAINING WALL WITH LEVEL AND SLOPING BACKFILL

EQUIVALENT FLUID PRESSURE = 28.7 LBS / FT³

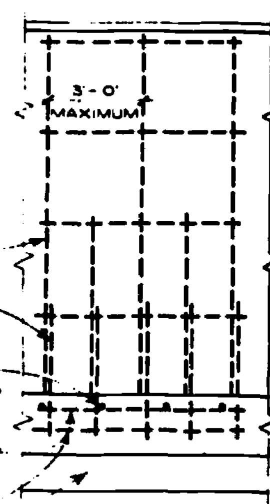
* BASE PRESS = BASE PRESSURE

from Bruce Schafer, Peoria, Illinois





SECTION



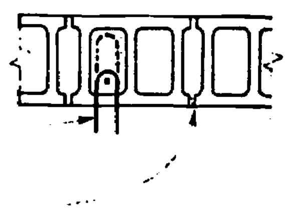
ELEVATION

YPICAL DETAILS OF CANTILEVER RETAINING WALL

MENSIONS AND REINFORCEMENT

ALL	H	B	T	A	VERTICAL RODS IN THE WALL	HORIZONTAL RODS IN FOOTING
THICKN-ESS	3'-4"	2'-4"	9"	8"	3 8" @ 32"	3 8" @ 27"
	4'-0"	2'-9"	9"	10"	1 2" @ 32"	3 8" @ 27"
	4'-8"	3'-3"	10"	12"	5 8" @ 32"	3 8" @ 27"
	5'-4"	3'-8"	10"	14"	1 2" @ 16"	1 2" @ 30"
	6'-0"	4'-2"	12"	15"	1 2" @ 24"	1 2" @ 25"
THICKN-ESS	6'-8"	4'-6"	12"	16"	3 4" @ 24"	1 2" @ 22"
	7'-4"	4'-10"	12"	18"	7 8" @ 32"	5 8" @ 26
	8'-0"	5'-4"	12"	20"	7/8" @ 24"	5 8" @ 21"
	8'-8"	5'-10"	14"	22"	7/8" @ 16"	3 4" @ 26"
	9'-4"	6'-4"	14"	24"	1" @ 8"	3 4" @ 21"

Vertical reinforcement is usually secured in place after the masonry work has been completed and before grouting. Accurately position and tie at vertical intervals not exceeding 160 bar diameters. Place wire loop extending into core in mortar joints as wall is laid up. Loosen before mortar sets. After inserting bar, pull wire loop and bar to proper position and secure wire by tying free ends. Control joints should be designed to resist shear and other lateral forces while permitting longitudinal movement.



PLAN DETAIL AT VERTICAL ROD AND CONTROL JOINT

ENERAL NOTES

ncrete masonry units for retaining wall construction ll comply with the requirements of "Specifications For llow Load Bearing Concrete Masonry Units," ASTM 0–64T.

ncrete for footings should be mixed in the following ap- ximate proportions: 1 part portland cement, 2 1/2 rts of sand and 4 parts of gravel. Gravel should be well ded and not exceed 1 1/2 inches in size. Amount of wa- used for each bag of cement should not exceed 5 1/2 lons unless the sand is very dry.

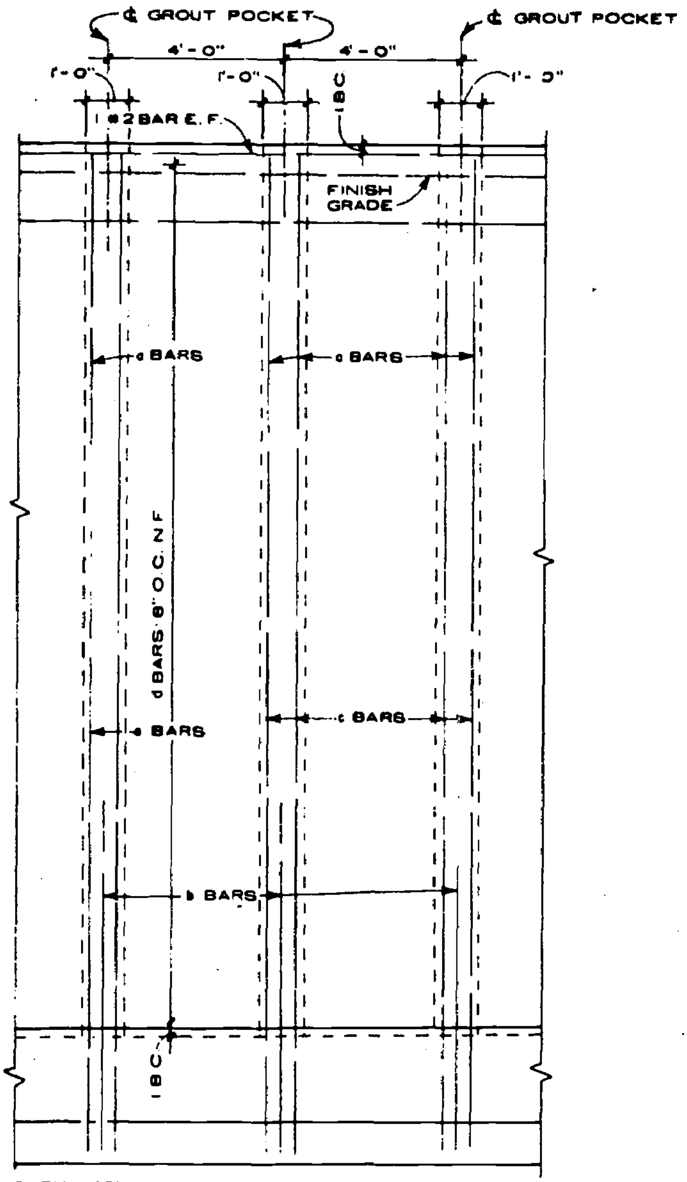
ortar and grout should comply with the requirements of pecifications For Mortar and Grout For Reinforced Ma nry," ASTM C476-63. Use fine grout where grout ace is less than three inches in least dimension. Use arse grout where the least dimension of the grout space is three inches or more. Aggregates for grout shall conform to ASTM Standard Specifications C404--61.

Steel reinforcement should be clean, free from harmful rust, and should comply with applicable ASTM standards for deformed bars and steel wire.

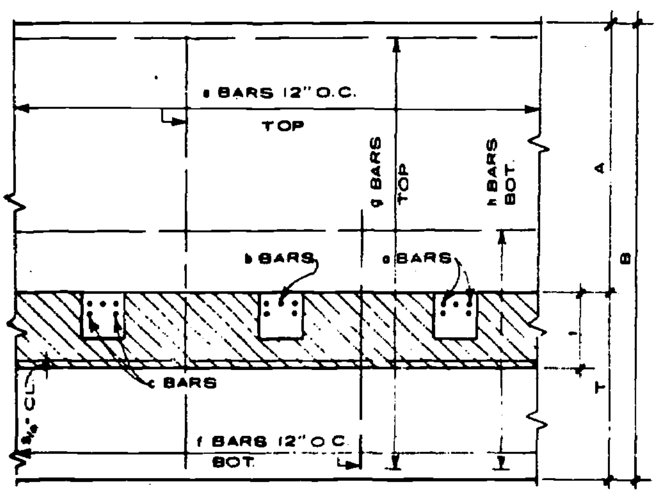
Designs herein are based upon an assumed soil weight (vertical pressure) of 100 pounds per cubic foot. Horizontal pressure is based upon an equivalent fluid weight for the soil of 45 pounds per cubic foot.

Walls shown are designed with a safety factor against overturning of not less than 2 and a safety factor against horizontal sliding of not less than 1.5. Designs are based on the following standards: Footings (ACI 318–63) and walls (ASA 41.2–1960). Computations in the table for wall heights are based on level backfill. One method of providing for additional loads due to sloping backfill or surface loads is to consider them as an additional depth of soil, that is an extra load of 300 pounds per square foot can be treated as 3 extra feet of soil weighing 100 pounds per square foot.

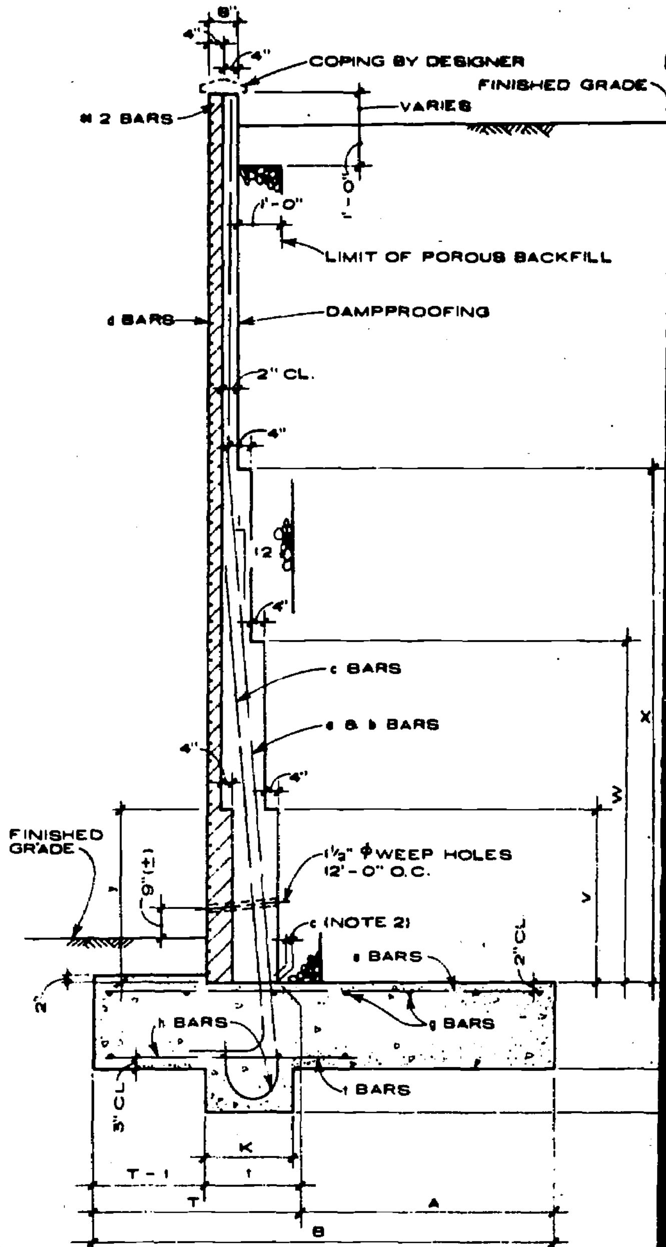
Allow 24 hours for masonry to set up before grouting. Pour grout in 4 foot layers, an hour between each pour. Break long walls into panels of 20 to 30 feet in length with vertical control joints. Allow 7 days for finished wall to set up before backfilling. Prevent water from accumulating behind wall by means of 4 inch diameter weep holes at a 5 to 10 foot spacing (with screen and graded stone) or by a continuous drain with felt covered open joints in combination with waterproofing.



ELEVATION



PLAN



SECTION

ABBREVIATIONS:

N.F : NEAR FACE
E F : EACH FACE
B C. : BRICK COURSE (STANDARD 3 COURSES PER 8 INCHES)
C L : CLEAR
BOT : BOTTOM
O.C. : ON CENTER

NOTE:

See following page for explanation of dimension symbols and design tables.

ay Products Institute; McLean, Virginia

ROUTED REINFORCED BRICK MASONRY CANTILEVER RETAINING WALLS

TEM									FOOTING							
mensions							Loads		Dimensions					Loads		
t.	t in.	C in.	V ft.	W ft.	X ft.	Y ft.	V kips per 4 ft.	/\ ft.-kips per 4 ft.	B	T	A	D	K	P kips per ft.	/\ or ft. kips per ft.	Toe pressure kips per sq. ft.
6	8	2					2.06	4.13	3'–6"	1'–3"	2'–3"	1'–0"		0.70	1.63	1.33
7	8	2					2.80	6.55	4'–0"	1'–3"	2'–9"	1'–0"		0.92	2.45	1.54
8	8	2					3.66	9.78	4'–6"	1'–3"	3'–3"	1'–0"		1.16	3.48	1.74
9	12	5			1		4.63	13.92	5'–0"	1'–6"	3'–6"	1'–0"		1.43	4.76	2.00
0	12	4			2		5.72	19.10	5'–6"	1'–9"	3'–9"	1'–0"		1.73	6.35	2.11
1	12	3			3		6.92	25.42	6'–0"	2'–0"	4'–0"	1'–3"	1'–3"	2.14	8.75	2.31
2	12	2			4		8.24	33.00	6'–6"	2'–3"	4'–3"	1'–3"	1'–3"	2.52	11.10	2.37
3	16	5		1	5		9.67	41.96	7'–0"	2'–6"	4'–6"	1'–3"	1'–3"	2.90	13.80	2.62
4	16	4		2	6		11.21	52.41	7'–6"	2'–9"	4'–9"	1'–6"	1'–6"	3.43	17.70	2.82
5	16	3		3	7		12.87	64.46	8'–0"	3'–0"	5'–0"	1'–6"	1'–6"	3.89	21.40	2.87
6	16	2		4	8		14.64	78.23	8'–6"	3'–3"	5'–3"	1'–6"	1'–6"	4.51	26.70	3.04
7	20	5	1	5	9	1	16.53	93.84	9'–0"	3'–6"	5'–6"	1'–9"	1'–9"	5.03	31.40	3.32
8	20	4	2	6	10	2	18.53	111.39	9'–6"	3'–9"	5'–9"	1'–9"	1'–9"	5.72	38.20	3.49
9	20	3	3	7	11	3	20.65	131.01	10'–0"	4'–0"	6'–0"	1'–9"	1'–9"	6.30	44.10	3.52
0	20	2	4	8	12	4	22.88	152.80	10'–6"	4'–3"	6'–3"	2'–0"	2'–0"	6.92	50.80	3.65

EINFORCEMENT

rs	a (2 per pocket)		b (1 per pocket)		c (2 per pocket)		d		e		f		g		h	
	Bar Size	Extension Above Top of Footing	Bar Size	Extension Above Top of Footing	Bar Size	Extension Above Top of Footing	Bar Size	No. of Bars	Bar Size	Length of Bar	Bar Size	Length of Bar	Bar Size	No. of Bars	Bar Size	No. of Bars
	# 5	Full Height of Pocket					#2	10	#3	3'–2"	#3	2'–3"	#3	4	#3	3
	# 6						#2	11	#4	3'–8"	#3	2'–3"	#3	4	#3	3
	# 6		# 6	3'–0"			#2	13	#4	4'–2"	#3	2'–3"	#3	4	#3	3
	# 7		# 6	3'–0"			#2	14	#5	4'–8"	#3	2'–6"	#3	4	#3	3
	# 7		# 7	4'–0"			#2	16	#5	5'–2"	#3	2'–9"	#3	5	#3	4
	# 8		# 7	4'–0"			#2	17	#6	5'–8"	#3	3'–0"	#3	5	#3	5
	# 8		# 8	5'–0"			#2	19	#6	6'–2"	#3	3'–3"	#3	5	#3	5
	# 8		# 8	6'–0"			#2	20	#7	6'–8"	#4	3'–9"	#4	5	#4	5
	# 9		#10	6'–0"			#2	22	#7	7'–2"	#4	4'–0"	#4	6	#4	5
	#10		# 9	5'–0"			#2	23	#7	7'–8"	#4	4'–3"	#4	6	#4	5
	#10		#11	6'–6"			#2	25	#8	8'–2"	#5	4'–9"	#4	6	#4	5
	#10		# 8	4'–0"	# 8	7'–0"	#2	26	#8	8'–8"	#5	5'–0"	#4	6	#4	5
	#10		# 9	4'–0"	# 9	8'–0"	#2	28	#8	9'–2"	#5	5'–3"	#4	7	#4	6
	#10		# 9	4'–0"	#10	9'–0"	#2	29	#9	9'–8"	#6	6'–0"	#4	7	#4	6
	#10		#11	5'–6"	#10	10'–0"	#2	31	#9	10'–2"	#6	6'–3"	#4	7	#4	6

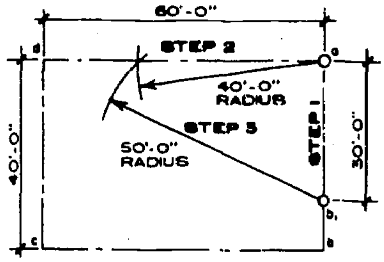
OTE:

The "c" dimension shown on the drawing and given in Table is the grout cover over the a and b bars at top of footing elevation.

The key on the bottom of the footing which resists sliding may be eliminated for walls with an H dimension of 10' and less.

In case the dimensions v, w, x and y shown in Table cannot be obtained with the brick used for the construction, the v, w and x dimensions should be increased and the y dimension decreased the distance required for the b[illegible] [illegible]urse out.

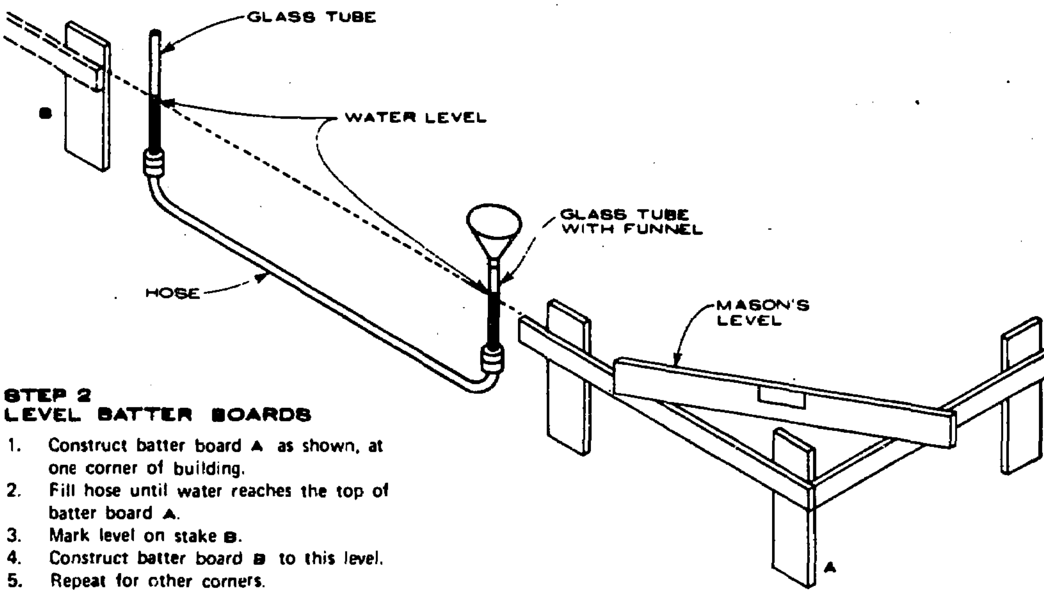
uct[illegible] ducts Institute; McLean, Virginia



BUILDING DIAGRAM

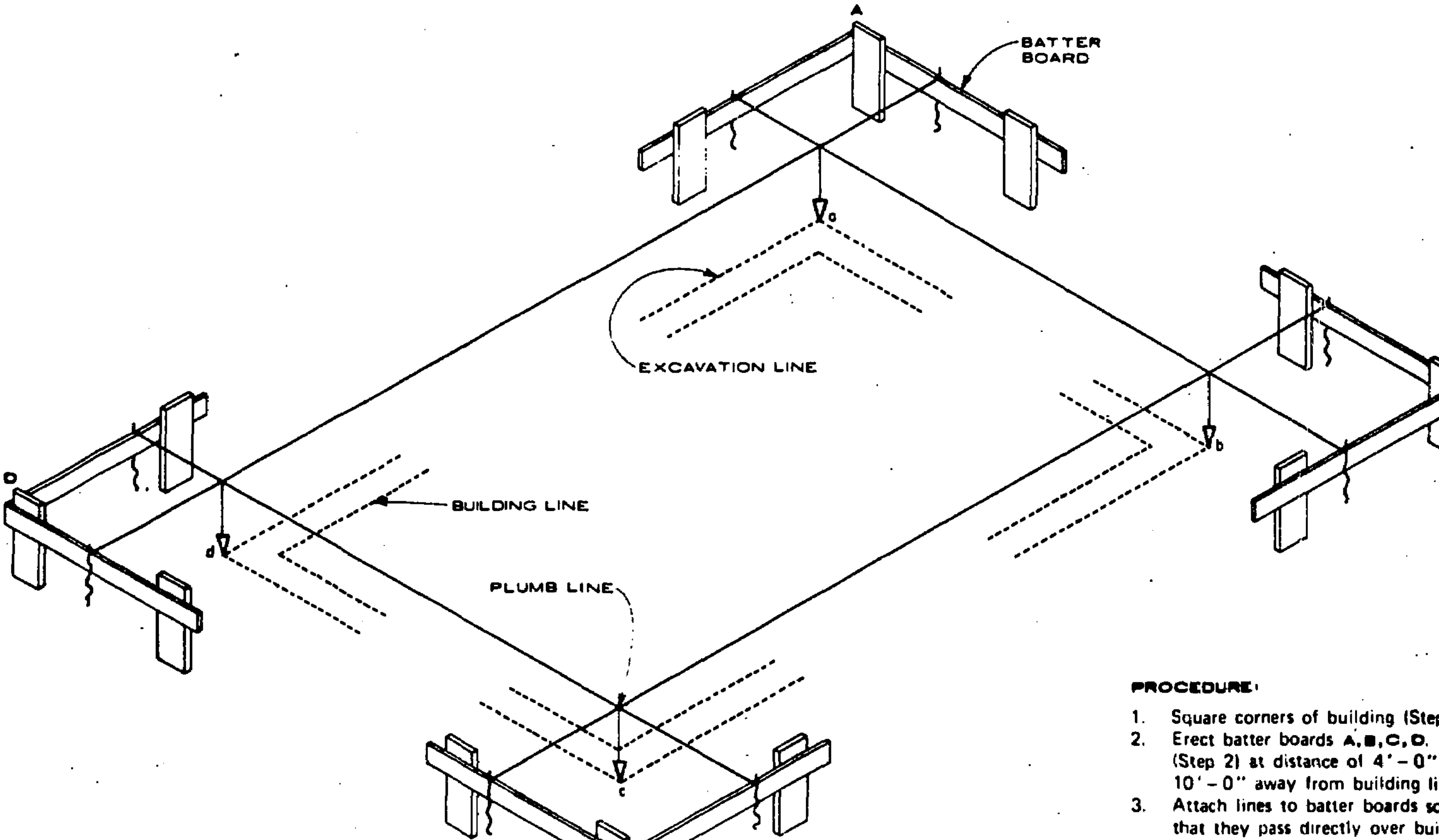
STEP 1
SQUARE BUILDING LINES WITH TAPE

1. "a" may be any corner of the building.
   "ab" may be along any side of the building.
2. See diagram.
3. See diagram.
4. Assume building is 40' – 0" x 60' – 0". Extend lines to full length of walls and mark corners with stakes.



STEP 2
LEVEL BATTER BOARDS

1. Construct batter board A as shown, at one corner of building.
2. Fill hose until water reaches the top of batter board A.
3. Mark level on stake B.
4. Construct batter board B to this level.
5. Repeat for other corners.



PROCEDURE:

1. Square corners of building (Ste
2. Erect batter boards A, B, C, D, (Step 2) at distance of 4' – 0" 10' – 0" away from building li
3. Attach lines to batter boards so that they pass directly over bui lines.
4. Establish limits of excavation a use the lines to check for squar ness and elevation during excav tion and construction.

STEP 3
BUILDING LAYOUT

CHAPTER VI

MASONRY CONSTRUCTION

The term brick means a clay brick manufactured of either clay or shale, dried and fired. Any other materials that are made into brick units, such as concrete, sand, lime, etc., must use a descriptive adjective relating to the material, i.e., slump stone.

Units with an area greater than 25% cored are referred to as tile or brick block.

The common brick materials are as follows:

Building Brick
Facing Brick
Glazed Structural Units
Clay Tile
Brick Block
Paving Brick

Building Brick is a term referring to the common or standard, or basic unit made of clay. The quality of a building brick is judged on its physical characteristics such as:

Grade
Compression Strength
Total Absorption
Initial Rate of Absorption
Visual Inspection

Grade: There are three grades of building brick:

1. SW - for use where a high degree of resistance to frost action and disintegration by weathering is necessary.

2. MW - for use where a moderate degree of resistance is required -- not likely to be permeated by water when exposed to freezing.

3. NW - used as a back up for interior masonry -- will disintegrate if subjected to freezing and thawing cycles.

Compression Strength: The load applied upon a brick unit in its normal position. In accordance with ASTM specifications, brick shall develop not less than:

3000 psi for SW
2500 psi for MW
1500 psi for NW

Total Absorption: This is measured in two ways:

1. 24 hour cold water exposure from which the amount absorbed is recorded as a percentage of total weight of the dry unit.

2. 5 hour boiling test from which the amount absorbed is also recorded as a percentage of the total weight of the dry unit.

The ratio of the two is the Cold Water/Boiling Water Ratio, or C/B ratio. Both the 5 hour boil and the C/B ratio have maximum allowable limits for each grade, established in the ASTM Standards. In southern California or any other area in the United States where the weather coefficient index is less than 100 this test can be waived. The C/B ratio is considered as a measure of the durability. It is presumably the measure of the ratio of easily filled pores to the total available, fillable pore space.

Initial Rate of Absorption: This is an entirely different measure of the total absorption. It is the measure of the amount of water a brick will absorb in a period of one minute, or, a measure of the rate at which the water is initially absorbed. Called "Initial Rate of Absorption" and expressed as "grams per 30 square inches per minute." It is not a measure of and cannot be related directly to total absorption.

Physical characteristics of a brick unit are important for a number of reasons:

1. If the absorption of a brick unit exceeds the proper rate, there normally will not be a good bond with the mortar. Tests have shown that the ideal rate of absorption is in the range of 10 to 12 grams up to about 20 grams per minute.

2. As brick units are laid in the wall the rate of laying becomes critical and difficult when water is lost from the mortar bed before the brick is placed on it.

3. An excessively high initial rate of absorption may require tapping on a brick wall, disrupting the bond between brick and mortar.

4. An extremely high initial rate of absorption will dry out the mortar so quickly that it will not retain enough water for strength and bond.

When the initial rate of absorption of a brick unit exceeds 20 grams per minute it is a code requirement that these units be wet to reduce their initial rate of absorption so as not to exceed 20 grams per minute at the time of laying.

This wetting should be done about 24 hours before the brick units are layed in the wall so that the water will fill the pores, reduce the rate of absorption and not leave a wet brick surface.

Building bricks are manufactured in a variety of colors and textures. The common standard building brick is terra cotta red. However, units of buff, salmon, orange, red or brown are also available. Brick texture is usually smooth, but also can be scored, wire cut, etc.

Sizes of building brick vary by type -- modular, oversize, jumbo, roman, norman, common, king size, etc.

<u>Visual Inspection</u>: Upon delivery to the job site it is absolutely necessary that the Inspector examine the bricks to assure compliance with the specifications. Samples supplied to the Architect/Engineer should be available for comparison of type, color, size, etc.

Minor flaws, indentations, surface cracks and minor chips resulting from customary handling of building bricks must be tempered with good judgment before rejection. Usually minor imperfections can be turned to the inside. The wall face must be free of imperfections detracting from the appearance when viewed from a distance of approximately 20 - 30 feet unless specifically spelled out in the specifications. Brick delivered to the job site shall contain not less than 95% whole brick (according to ASTM C62).

<u>Facing Bricks</u> are manufactured for the distinct purpose of becoming an exposed face of a masonry wall.

<u>Grade</u>: There are two grades of facing brick:

1. SW for severe weather.

2. MW for moderate weather.

There is no NW grade since these bricks are not intended for use as backups.

Type: There are three types of facing brick:

1. FBS - for general use or wider color ranges and greater variation in sizes are permitted.

2. FBX - for general use in exposed surfaces where a high degree of mechanical perfection, narrow color range and a minimum permissable variation in size are permitted.

3. FBA - selected to produce characteristic architectural effects.

NOTE: If no type of facing brick is specified, the basic requirements of type FBS will be supplied.

Visual Inspection: The face or faces of the brick units must be free of imperfections detracting from the appearance of a wall when viewed from a distance of 15 feet for FBX and no feet for types FBS or FBA.

Glazed Structural Units are ceramic glazed structural clay facing tile.

Grade: There are two grades of glazed structural units:

1. S (Select) - for use with comparatively narrow mortar joints.

2. G (Ground Edge) - for use where variation of face dimensions must be extremely close.

Type: There are two types of glazed structural units:

1. Type I - Single faced unit for general use where only face will be exposed.

2. Type II - Two faced units for use for opposite finished faces.

NOTE: Grade S in Type II is available in 3 3/4 inch thickness only.

Clay Block are hollow units very similar in shape to concrete block. However, they are made of dried and fired clay similar to brick. They are not classed as tile because of the spacing of the webs and cells. They are permitted under codes for values similar to the stresses used for concrete block for "hollow" and "hollow units filled solid" although they are generally higher in strength than concrete block.

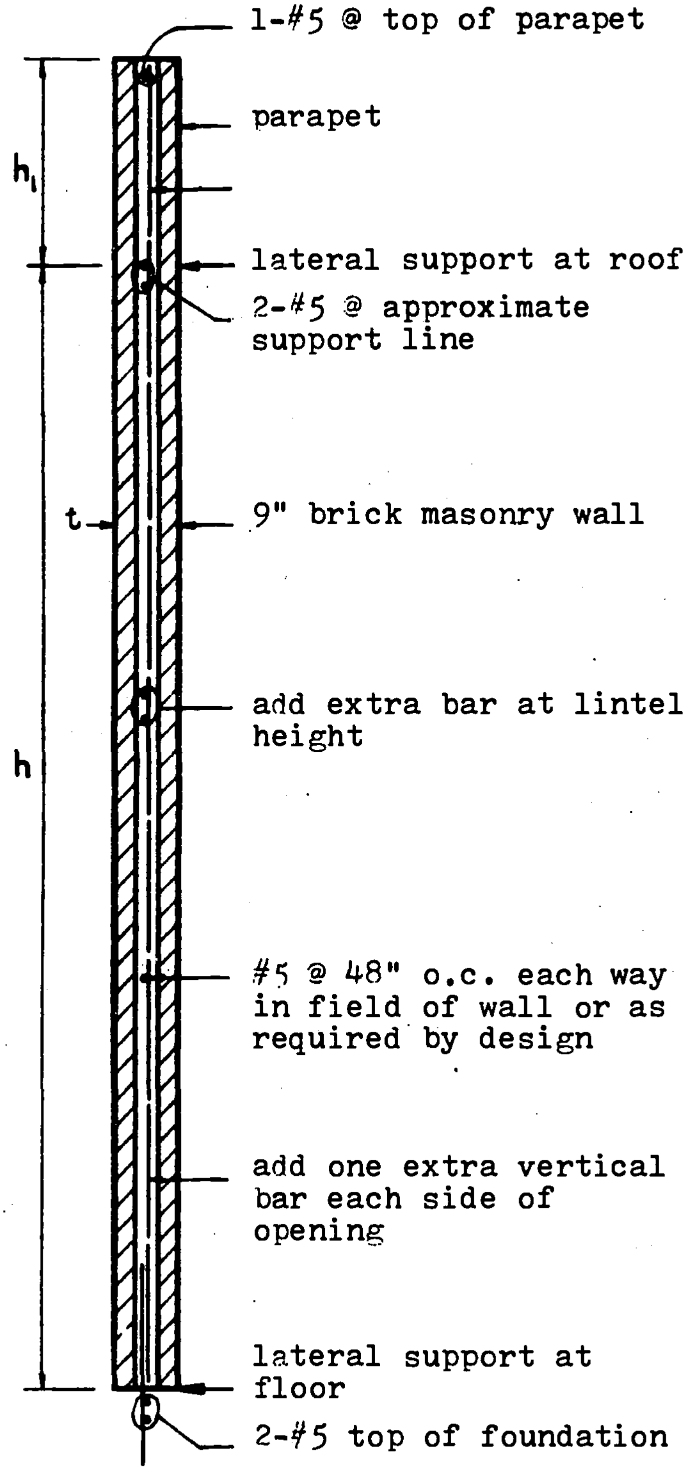
Details of Construction: On the following pages 68 through 131 are some details of typical type construction. As these are just general in nature they must be checked by the Architect/Engineer for suitability to the particular project.

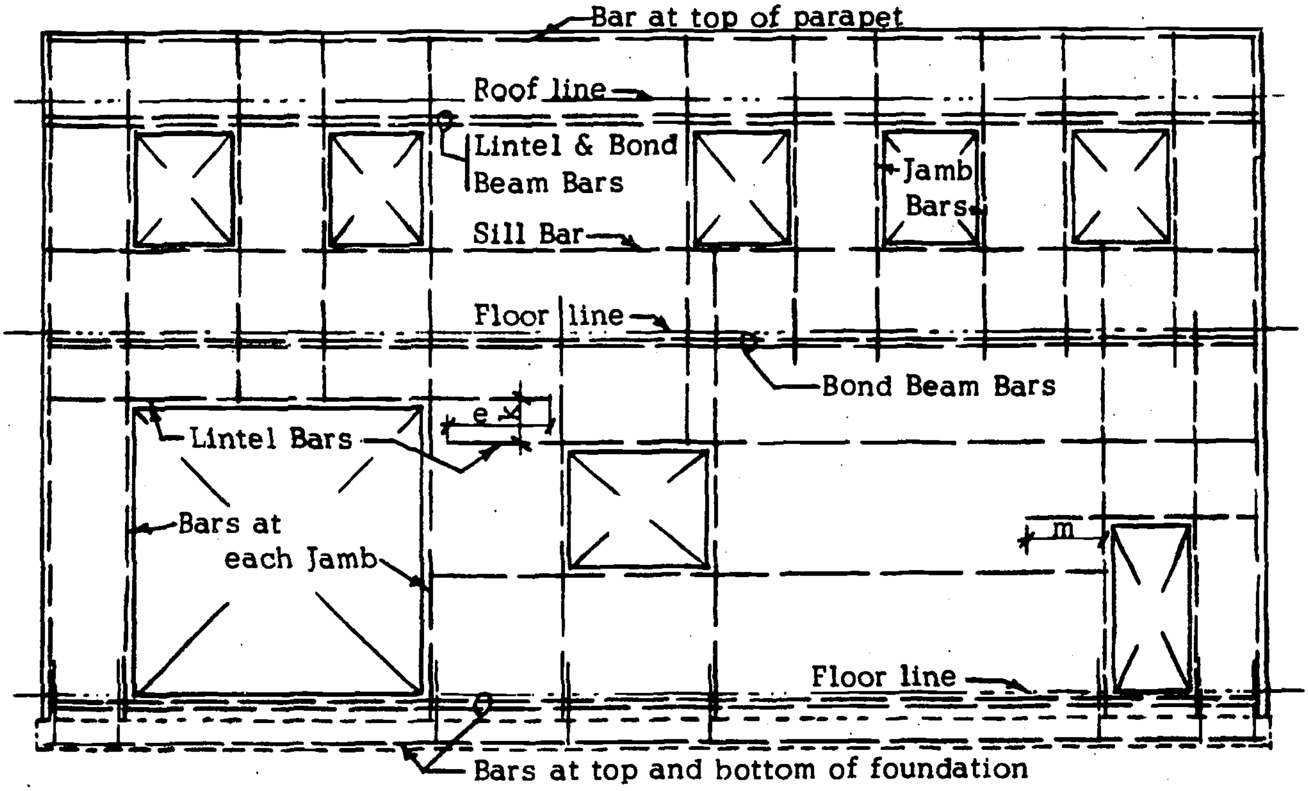
Joints: Since masonry consists of a series of joints, the joinery is an important facet of masonry work. Some typical joints are shown on page 96.

9" Reinforced Grouted Brick Masonry Wall

The design of a parapet wall and the vertical reinforcing required is generally governed by the lateral seismic load assumed imposed on the wall.

The design of the wall between lateral supports is dependent upon the height of the wall and the loads imposed.





Recommended reinforcement is shown in this elevation. In the field of the wall there should be added to this requirement the reinforcing required by the Building Code and loads imposed on the wall.

The distance "m" should be not less than 48 bar diameter, 24 inches or the distance between vertical bars, whichever is greater.
In order to consider continuity of bars in the wall the distance "e" should be at least twice the distance "k". Where the lintel is within 24 inches of the roof line the same bars may serve for the bond beam and lintel.

REINFORCED MASONRY CONSTRUCTION

Exterior walls, partitions and all masonry elements will be reinforced with steel. Layout and details of construction shall be compatible with the application of the rules for modular measure. Masonry shall conform to one of the following basic types: (1) reinforced hollow unit masonry, (2) reinforced faced (composite) masonry, or (3) reinforced grouted (solid) masonry. These three basic types of construction are illustrated by Figures 6-1, 6-13 and 6-14, respectively. Cavity walls will not be used, unless each wythe is individually designed as an independent structural wall.

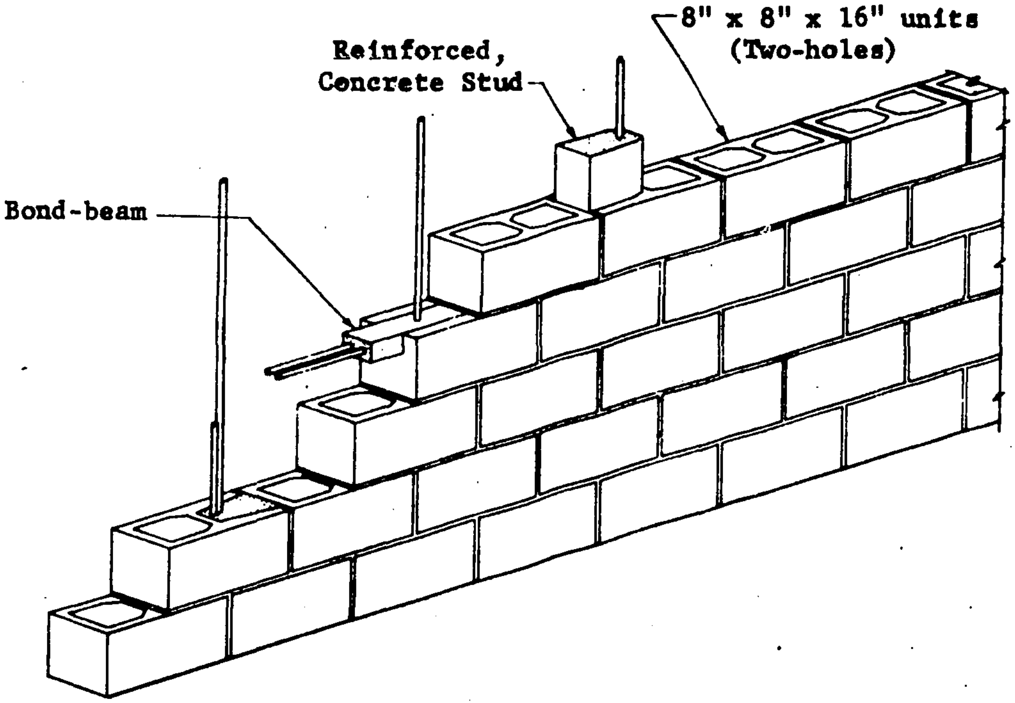


FIGURE 6-1 Reinforced Concrete Unit Masonry

Height Above Grade Limitation. Except in skeleton construction of structural steel or reinforced concrete, reinforced masonry will not be used in any portion of a structure where that part of the structure exceeds 36-feet in height above adjacent ground level. Non-structural masonry partitions may be used in skeleton construction, above the 36-feet, provided isolation compatible with the floor-to-floor drift is assured by the detailing.

Bond-Beams. A bond-beam is a horizontal course of hollow masonry with steel reinforcement bars embedded in concrete corefill. The principal purpose is to provide structural integrity and in turn crack-control. The bars will be lapped 40-diameters or 2-feet, whichever is greater, at splices and at corners. Bar splices will be staggered. Bond-beams will be provided at top of masonry foundation wall stems, below and at top of openings or immediately above lintels, at floor and roof levels, and at top of parapet walls. Intermediate bond-beams will be provided at 48-inches on vertical centers, except that whenever the height is not a multiple of 4-feet the spacing may be increased up to a maximum of 72-inches provided the bond-beams are supplemented with joint reinforcement. One-line of joint reinforcement will be provided for each 8-inch increase in the spacing in excess of 48-inches. No additional bond-beams will be required between window openings which do not exceed 6-feet in height provided the prescribed supplemental joint reinforcement is installed. To facilitate placement of steel or concrete corefill, the top bond-beam for filler walls or partitions may be placed in next to top course. The area of bond-beam reinforcement shall be included as a part of the minimum horizontal steel required by TABLE 6-2.

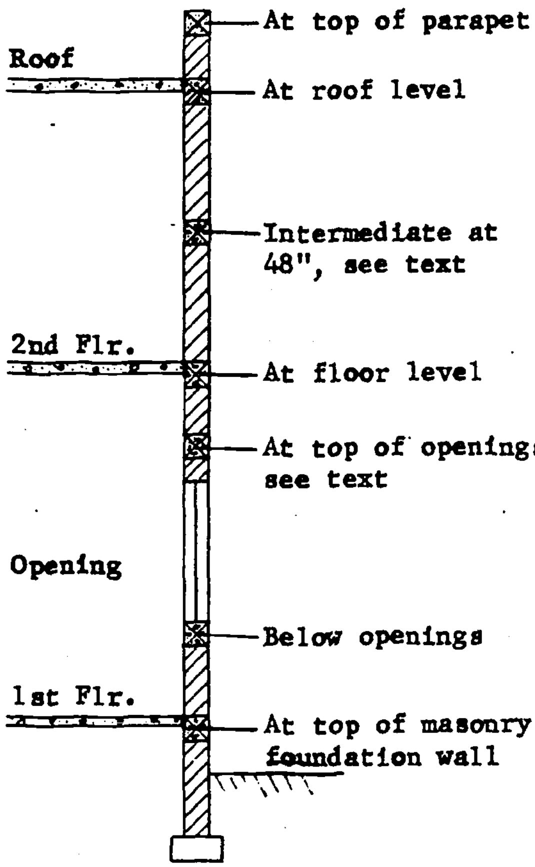


FIGURE 6-2 Location of Bond-Beams

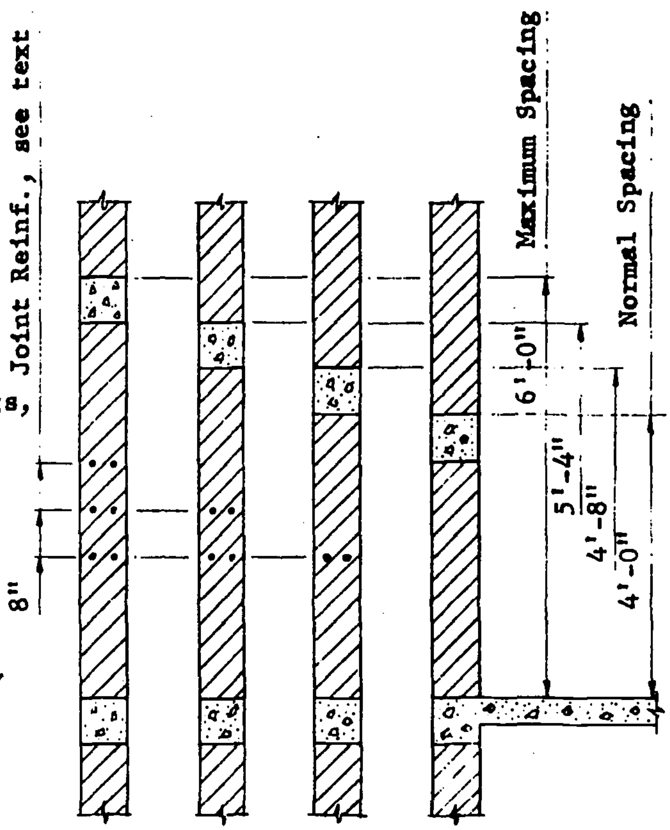


FIGURE 6-3 Joint Reinforcement with Intermediate Bond-Beam

Lintel-Beams. Lintels are formed by placing beam units over openings and reinforcing with minimum of 2-#4 bars embedded in concrete corefill. Reinforcement shall extend 40-bar diameters or 2-feet, whichever is greater, beyond each face of opening; reinforcement shall be supported by wire chairs to insure proper coverage of steel. Steel stirrups will be provided as required. Bond-beams serving as lintels shall be provided with supplemental steel.

Concrete-Studs. Concrete-studs are formed by incasing the vertical reinforcement in concrete-corefill in cells of hollow masonry units. Studs shall be continuous from foundation to top of wall. Generally, the length of vertical reinforcing will be such that it extends from floor-to-floor (or roof) level, and at least the required lap distance (not less than 40-diameters) above top of the bond-beam whenever additional units are to be laid. Where necessary to splice reinforcement in the middle half of span, bar splices will be staggered. Spacing and reinforcement of studs will be determined by design, but in no case less than that required by TABLE 6-2.

Joint-Reinforcement. Joint-reinforcement consists of two or more longitudinal wires held in a parallel position by cross wires welded at regular intervals to the longitudinal wires. Joint-reinforcement will be fabricated from zinc-coated steel wire, either smooth or deformed. During construction each longitudinal wire will be embedded in mortar in specified horizontal joints. Joint-reinforcement is used to supplement bond-beam reinforcement, and to bond faced construction for composite action, see Bond-Beams, page 71, and Faced Construction, page 80, respectively. Additional joint-reinforcement may be necessary for crack-control, see Crack-Control Design, page 79.

Control-Joints. Control-joints in masonry construction are vertical wall joints which provide a complete separation through the entire thickness of masonry and joint-reinforcement. Reinforcement in structural bond-beams will be continuous with a dummy joint in alignment with the control-joint. Control-joints permit longitudinal deflection and movement without differential transverse displacement. In effect, control-joints separate a wall into panels, thereby reducing the tensile shrinkage stresses which cause cracking, and establishes the length of the vertical resisting elements which in turn fix the rigidities to be used in distributing lateral forces. For location and spacing of joints see Crack-Control Design, page 79.

Masonry-Wall Coursing. Each wythe of masonry walls will normally be constructed in running bond, all stretchers, with staggered head joints. Stack-bond will be limited to comparatively small areas where required for architectural purposes. Stack-bond shall require joint reinforcement at 8-inch vertical centers.

Walls and Partitions. All masonry walls and partitions will act as a structural element unless isolated from the structure. Masonry walls may be bearing walls with or without pilasters, curtain walls, filler walls, or partition walls. Combinations often occur. Any wall or partition which carries a vertical load other than its own weight or which resists a horizontal force, parallel to the wall, is classified as a structural wall. Any wall which is isolated on 3 sides so as not to resist external loads or forces is classified as non-structural. Unisolated walls obviously participate in shear resistance to horizontal forces parallel to wall for they tend to deflect and be stressed when the framework or horizontal diaphragms yield under lateral forces. The relative rigidity of masonry walls with normal openings is usually much greater than that of the building framework. Thus, the walls will transfer a large part of the lateral forces. For crack-control as required hereinafter, walls and partitions may be divided into separate panels, which are designated vertical resisting elements. The distribution of lateral forces to these vertical resisting elements is dependent upon the relative stiffness of the various vertical resisting elements at a particular level. Therefore, the location of control-joints must be established before any lateral force distribution is made.

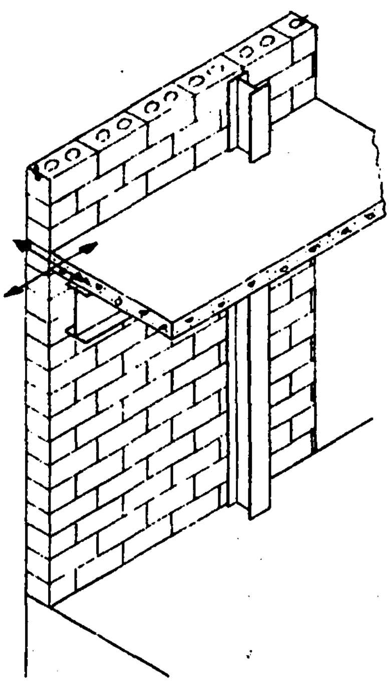


FIGURE 6-4
Curtain Wall

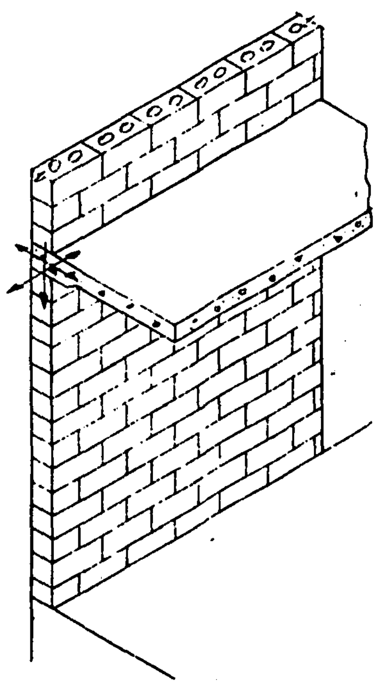


FIGURE 6-5
Bearing Wall

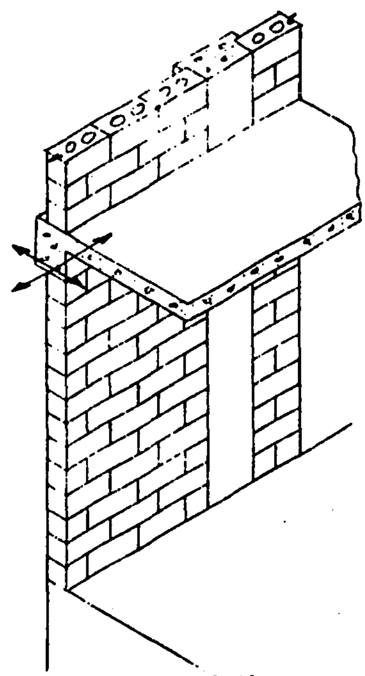


FIGURE 6-6
Filler Wall

In addition, walls and partitions must safely resist horizontal loads normal to their faces; and transverse lateral deflections must be controlled by diaphragm deflections so as to prevent overstress. Masonry walls and partitions will be designed to withstand all vertical loads and horizontal forces, both parallel and normal to face, with dur allowance for the effect of any eccentric loading. Corbeling will not be permitted.

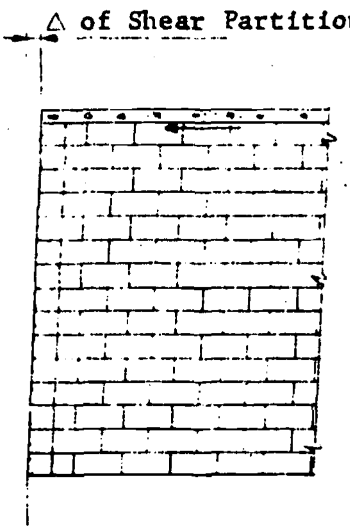


FIGURE 6-7
Wall Restrained by Shear Partition

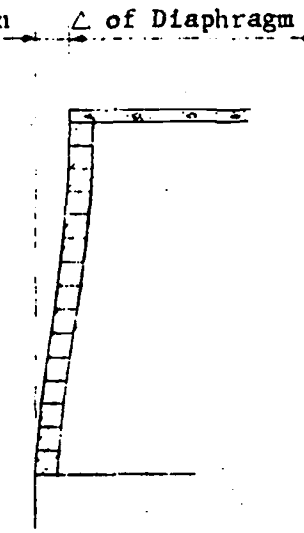


FIGURE 6-8
Unrestrained by Shear Wall

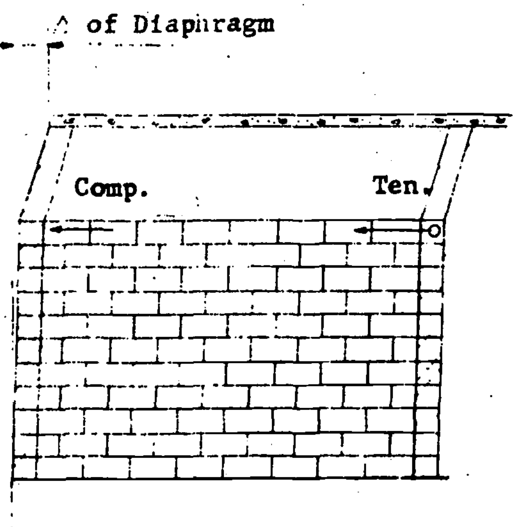


FIGURE 6-9
Wall Restrained by Low Unisolated Partition

1. Height and Thickness Limitations. The minimum nominal thickness, and the ratio of unsupported span to thickness will be governed by the following table:

TABLE 6-1

HEIGHT AND THICKNESS LIMITATIONS

TYPE OF WALL	NOMINAL MINIMUM THICKNESS (Inches)	MAXIMUM RATIO UNSUPPORTED SPAN TO THICKNESS
Exterior Walls	8	24
Structural Partitions	6	24
Non-Structural Partitions	6	36

The unsupported height of wall ("H") shall be measured between points of lateral supports. Such point of lateral support shall be interpreted to mean a point of anchorage to a horizontal resisting element or structural member, provided such member is designed to carry lateral loads, and in turn is laterally supported by means of vertical resisting elements. At slab-on-grade the point of lateral support shall be taken as the floor line if the walls are anchored to the slab; otherwise it shall be considered as a point 2-feet below the finished grade or at the floor line, whichever is lower. Occasionally, details of construction can be such that the unsupported span and direction of principal reinforcement may be based on the horizontal span rather than the vertical height. This is not the usual case due to a number of factors, such as location of wall openings, magnitude of vertical loads or lateral forces, lack of vertical resisting elements, and need to isolate partitions for crack-control or to direct path of lateral force distribution. However, for those cases where the use of horizontal spans is appropriate, the requirements of TABLE 6-2 relative to vertical and horizontal reinforcement will be interchanged, both as to maximum spacings and percentages of minimum reinforcement. Pilasters used for lateral support shall be capable of providing this support, and in turn be supported by horizontal resisting elements. The thickness of wall ("T") shall be considered the nominal face to face dimension, including any facings which are bonded for composite action. No masonry wall or partition thickness will be less than that indicated in TABLE 6-1 for the respective type of wall.

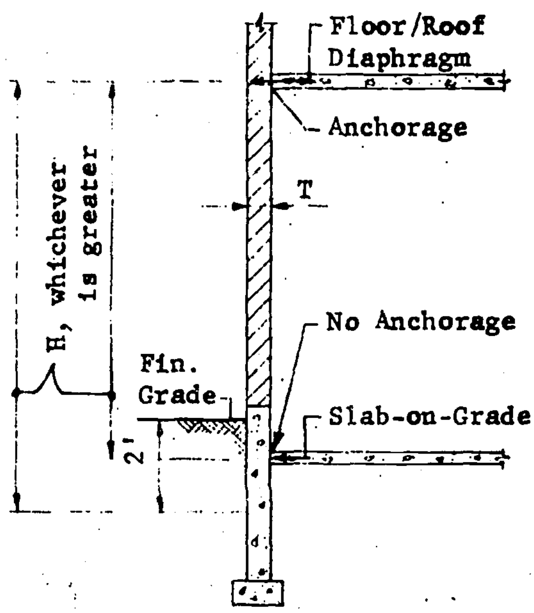


FIGURE 6-10
Unsupported Height Without Anchorage

2. Minimum Reinforcement. All walls and partitions will be reinforced with both vertical and horizontal bars. Masonry will be reinforced not only for structural strength but to provide ductile properties and to cause it to "hold together" in the event of severe seismic disturbance. Wall reinforcement will be as required by structural calculations, but in no case, less than the minimum area of steel and the maximum spacing of bars required by TABLE 6-2. Only reinforcement which is continuous in the wall element will be considered in computing the minimum area of reinforcement. In addition, joint-reinforcement will be provided as required hereinafter for crack-control and for bonding of facings, if any. Joint-reinforcement used for crack-control or bonding may be considered as part of the total minimum horizontal reinforcement, but will not be used to resist computed stresses. However, additional reinforcement will be provided at openings, corners, anchored intersections, and at ends of panels (vertical resisting elements) as designated elsewhere in this section.

TABLE 6-2:

MINIMUM WALL REINFORCEMENT

TYPE OF WALLS	VERTICAL BARS				HORIZONTAL BARS	
	SEISMIC ZONE 3		SEISMIC ZONES 1&2		ALL SEISMIC ZONES	
	MAX SPACING (Inches)	P_g(2)	MAX SPACING (Inches)	P_g(2)	MAX SPACING (Inches)(1)	P_g(2)
EXTERIOR	24	.0014	32	.0010	48	.0007
PARTITIONS:						
Structural	24	.0014	32	.0010	48	.0007
Non-Structural	32	.0010	48	.0007	48	.0007

(1) Bond-beam spacing may be increased to 72-inches under conditions stated in the Bond-Beam paragraph, page 71, except when principal reinforcement is horizontal.

(2) Ratio of area of reinforcement to gross area of masonry section, nominal dimensions (i.e. Area of bars/thickness of wall times spacing of bars).

<u>Columns</u>. Masonry columns (pilasters) will be constructed of reinforced masonry as required by this section, and will be designed to withstand all horizontal and vertical loads. Masonry columns or pilasters will not be used to qualify a structure for a complete vertical load-carrying space frame to reduce the factor "K" below 1.33 (box system). Masonry columns will not be used in rigid frame construction.

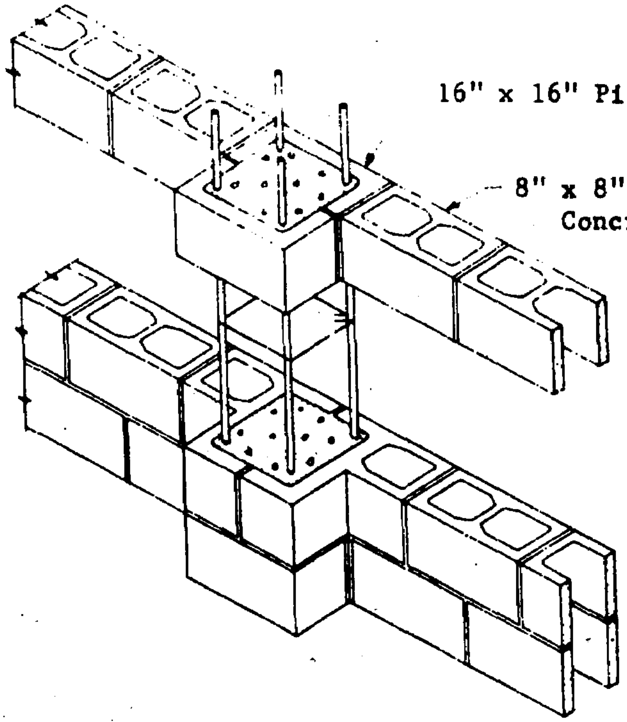


FIGURE 6-11 Hollow Unit Masonry Pilaster

1. Limiting Dimensions. The least nominal dimension of every masonry column or wall pilaster will be not less than 12-inches. No masonry column will have an unsupported length greater than 18 times its least nominal dimension.

TABLE 6-3

HEIGHT OF COLUMN LIMITATION					
LEAST DIMENSION (Inches)	12	14	16	20	24
MAXIMUM HEIGHT (Feet)	18	21	24	30	36

2. Vertical Reinforcement. Vertical reinforcement will be neither less than .005 A_g nor more than .04 A_g, Where A_g is gross area of column. Not less than 4-#4 bars will be used. Bars will be lapped 30 bar diameters. Welded splices will be full butt welded.

3. Lateral Ties. Hoop ties will be not less than 1/4-inch in diameter and will be spaced apart not over 16 bar diameters, 48 tie diameters, or the least nominal dimension of the column. Lateral ties will be placed not less than $1\frac{1}{2}$-inches nor more than 5-inches from the surface of the column. Column ties will be in contact with the vertical steel.

Wall Piers. **Masonry wall piers** will be designed to withstand all horizontal and vertical loads. Every pier or wall section whose width is less than three times its thickness or 24-inches, whichever is greater, will be designed and constructed as required for columns. Every pier or wall section whose width is between three and five times its thickness or less than one-half the height of adjacent openings will have all horizontal steel in the form of ties, which may be in the form of hairpins.

Openings in Walls. For all exterior walls and structural partitions, provide at least 1-#4 deformed bar on all sides of, and adjacent to every opening which exceeds 2-feet in either direction. Such perimeter bars will extend not less than 24-inches beyond the corners of the openings. In cases where the opening exceeds 4-feet in width, these extra vertical bars will extend from diaphragm-to-diaphragm (floor-to-floor, or floor-to-roof). The perimeter bars required by this paragraph will be in addition to minimum reinforcement otherwise required, except over opening where the total combined depth of lintel and bond-beam is not less than 16-inches (i.e. where a bond-beam is immediately above a lintel). Whenever the cavity adjacent to opening is occupied by reinforcement otherwise required, locate perimeter bar in next adjacent cavity.

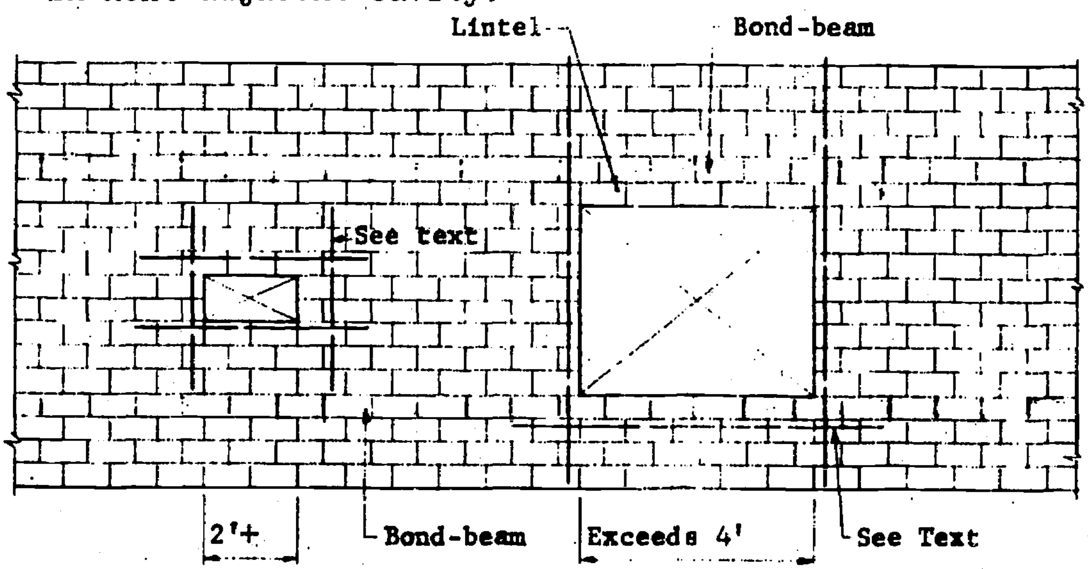


FIGURE 6-12 Additional Reinforcement Around Openings

Vertical Support. Vertical supports of masonry (e.g. girders, beams and floors) will be limited to non-combustible construction. The vertical support will be such that the ultimate deflection of the support under all design dead and live loads will not exceed L/360, where L is the clear span of the support. To limit settlement cracking, it is essential that temporary shores be removed before erecting masonry.

Lateral Support. Exterior walls and shear partitions shall be anchored to the structural frame or diaphragm (horizontal resisting element) by dowels, stud bars or other approved methods to withstand applicable horizontal forces, normal to face, but in no case less than 200 lbs per foot of wall. Dove-tail anchors are inadequate for this purpose. Non-structural partitions should be isolated from exterior walls and shear partitions so as to prevent buttress action which would restrict shear walls from deflecting with the diaphragms. Isolated masonry partitions shall be braced to overhead construction or anchored to other isolated cross-walls to assure lateral stability. Wedges will not be used between top of partition and framing.

Crack-Control Design. Cracking of walls constructed with concrete-masonry-units is caused by the development of tensile stresses within the wall assembly which exceed the tensile strength of the materials comprising the assembly. For other than structural conditions, the principal causes of tensile stresses are volume change in the masonry-wall materials and restraint from structural frames or cross-walls. Volume reduction is caused chiefly by temperature contraction, and drying (moisture loss) shrinkage. The capacity of a wall to resist tensile stress is a function of the strength and the arrangement of all the materials in the construction, which act in combination to accommodate accumulated stresses. The properties of a masonry-mortar system can be influenced by environmental factors and aging processes, to a degree dependent primarily on material quality, curing methods, and installation practices. Several crack-control methods have been developed, such as control joints, elimination of cross-wall restraints, bond-beams, joint reinforcement, and specified limits on linear-shrinkage potential of the materials. Each building will be carefully analyzed by the designer, and a crack-control plan developed suitable for the particular conditions of materials, detailing features, and size and configuration of the building with full consideration given to the rigidity and stress-force distribution for the seismic forces. The following minimum crack-control measures will be provided for all concrete-masonry unless the smallness of the structure, say 40-foot length, precludes their use:

1. Location and Spacing of Control-Joints. For concrete-masonry, control-joint spacing should not exceed 50-feet except that the distance from corner should not exceed 25 feet. Control-joints should be located: at changes in wall height or wall thickness; at wall intersection of L-, T-, and U-shaped buildings, unless seismic joints have been provided; where walls abut (except at corners), connect, or frame into each other. Provide dummy joints in alignment with the control-joints; in continuous (structural) bond-beams, concrete spandrels, and foundation walls. Horizontal joint reinforcement and bars in non-structural bond-beams will be terminated at all control-joints; deformed bars in structural bond-beams will be made continuous, with dummy-joint to coincide with the control-joints.

2. Moisture-Control of Concrete-Masonry-Units. Since location of wall joints determines the rigidity of the walls, and in turn the distribution of seismic forces and the resulting unit stresses, adding, eliminating or relocating control-joints will not be permitted, once the design is complete. Therefore, the shrinkage potential of the masonry must be fixed during the design. To assure units will be compatible with design assumptions, field control of moisture-content of concrete-masonry-units should be established by the project specifications.

Faced Construction. Faced construction is hollow concrete-masonry which is faced with glazed structural units or brick. The facings will be laid in running bond as the work progresses, and anchored to the reinforced hollow masonry backup by joint reinforcement placed at 16-inch vertical spacing to form composite construction. The joint between facing and hollow unit masonry will be completely filled with mortar. In case of glazed structural units, the faces of bases and wainscots will be set flush with the wall above. To permit placing of vertical bars on center-line of composite wall, the backup units for vertical reinforcement will be of special shapes without interior face shell on those cells with vertical bars. TABLE 6-2 applies.

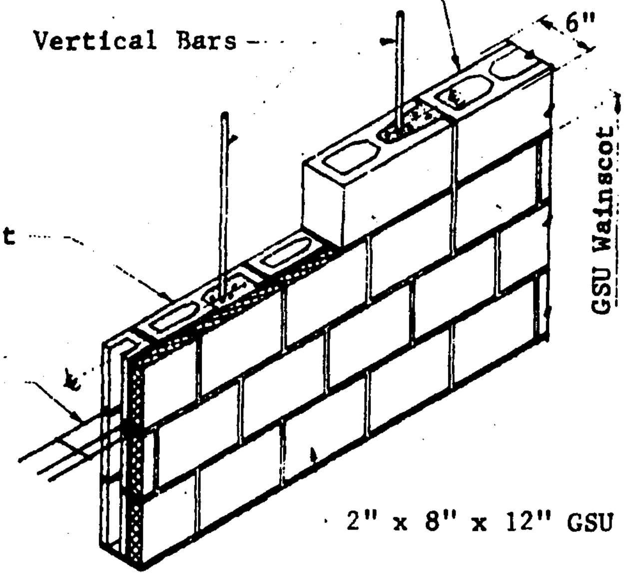


FIGURE 6-13 GSU-Faced Concrete-Masonry (Composite Construction)

Special GSU Construction. Partitions constructed with GSU exclusively will be limited to pipe spaces, dwarf or stub partitions, and to areas where partition requires two GSU faces. Whenever both faces are exposed to view, the GSU partition thickness will be composed of two units to maintain flush alignment of each face. All GSU partitions will be reinforced with deformed bars, both vertically and horizontally. TABLE 6-2 applies.

Grouted-Brick Construction. Grouted-masonry walls are made of brick in which the collar joints, the inside lengthwise vertical joints between tiers of brick, are reinforced vertically and horizontally, and filled solidly with concrete grout. Longitudinal vertical joints will be a minimum of 2-1/2 inches wide, and be reinforced with deformed bars, both vertical and horizontal. TABLE 6-2 applies. All units in the two outer wythes will be laid in running bond with full shoved head and bed mortar joints. Masonry headers will not project into grout spaces. Clipped-brick headers will be used where the appearance of masonry headers is required. In members of three or more tiers in thickness, interior bricks will be embedded into the grout so that at least 3/4-inch of grout surrounds the entire brick. Reinforced grouted masonry construction will be limited to clay or shale brick, unless option for concrete brick or split block is shown or noted on the drawings.

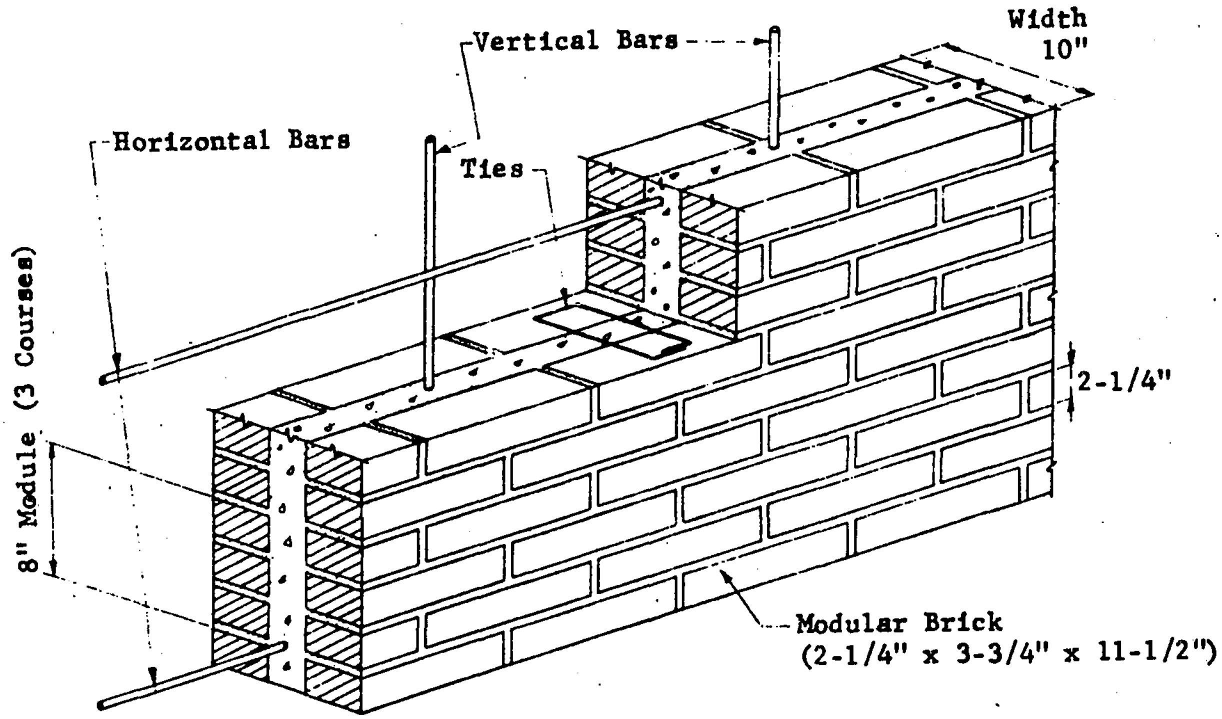


FIGURE 6-14 Reinforced Grouted Brick Masonry

<u>Connections to Other Elements</u>. The use of joints and connections for the transmission of shears, axial loads, moments and torsions from diaphragms to walls and from walls to sub-structure is inherent in seismic design. Great care must be taken to properly design connections between the vertical resisting elements (shear walls) and the horizontal resisting elements (floor and roof diaphragms) so as to make such walls an integral part of the structural system. Positive means will be provided for transferring shears <u>from</u> the plane of the diaphragm into the vertical resisting elements, and also for transferring wind or seismic forces from the vertical elements into the diaphragms. In designing connections or ties, it is necessary to carry out the forces and their stress paths (according to relative regidity) and also to make each and every connection along each path adequate and consistent with the basic assumptions and distribution of forces. Because joints and connections directly affect the integrity of the structure, their design and fabrication must be adequate for the functions intended. In designing and detailing, it is well to keep in mind that the lateral forces are not static, as assumed for convenience, but dynamic and to some extent unpredictable.

1. Forces to be Considered in the design of joints and connections are gravity loads, temporary erection loads, differential settlements, horizontal loads normal to wall, horizontal forces parallel to wall, and creep, shrinkage and thermal forces -- separately or combined as applicable. Bond-beams acting as flange (chord) for horizontal diaphragms will require reinforcement to be continuous at dummy control-joints for tensile and compressive chord stresses induced by the diaphragm beam action, and the marginal connections must be capable of resisting the flexural and shear stresses developed. Provisions will be made in the design of connections to force lateral movements in walls arising from creep, temperature and shrinkage movements in decks including steel beams or girders when decking is fastened thereto. Joints and connections should occur at logical locations in the structure, when practical, at points which may be most readily analyzed and easily reinforced. Rotational forces resulting from eccentric connections must be provided for. In general, elements and members should be detailed so that torsion and moments are held to a minimum at the connections.

2. Joints and Connections may be made by welding steel reinforcement to structural steel members, by bolting, by dowels, by transfer of tensile or compressive stresses by bond or anchorage of stud bars, or by use of key-type devices. The transfer of shear may be accomplished by using reinforcing steel extended as dowels coupled with cast-in-place concrete placed between roughened concrete interfaces, mechanical devices such as embedded plates or shapes. The entire shear should be considered as transferred through one type of device, even though a combination of devices may be available at the joint or support being considered. All significant combinations of loadings should be considered, and the joints and connections should be designed for forces consistent with all possible combinations of loadings. Details of the connections shall admit to a rational analysis in accordance with well-established principles of mechanics.

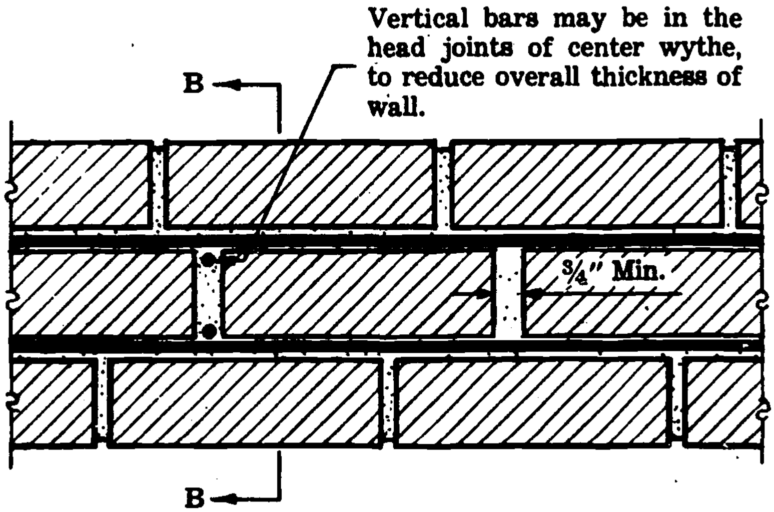
3. Cautionary Notes for Inspectors. Avoid welding to any embedded metal items which might cause damage to the adjacent masonry by spalling, in particular where the expansion of the heated metal is restrained by masonry. All bolts and dowels which are embedded in masonry will be grouted solidly in place with not less than 1-inch of grout between the bolt or dowel and the masonry. At tops of piers and columns, vertical bolts will be placed 4-inches from the face of the masonry and will be set inside the horizontal ties.

4. The Strength of a structure should be governed by the strength of the structural elements rather than by the strength of the connections; the connections should not be

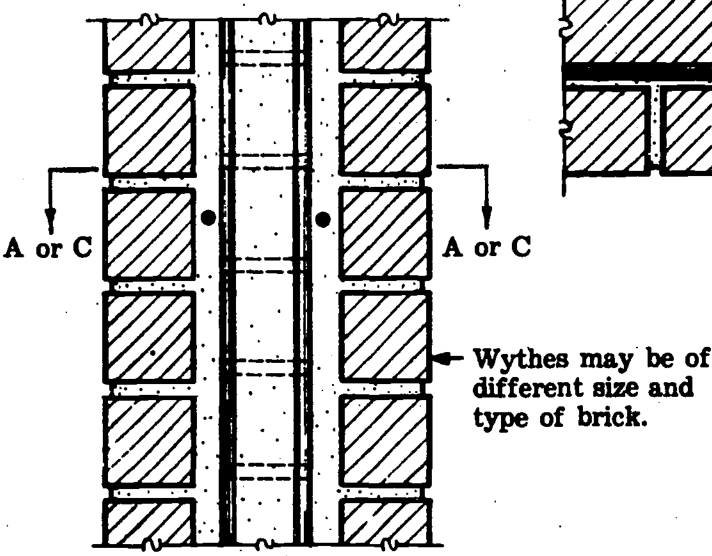
the weak link in the structure. The design forces for joints and connections will be at least 20-percent in excess of that required of the elements connected, and in no case less than 200 pounds per linear foot.

Drawings. The locations of control joints, and the identification of structural and non-structural walls and partitions for all masonry construction will be shown on preliminary and contract drawings. On contract drawings show complete details for masonry, reinforcement, and connections to other elements. Detailing procedures outlined in ACI 315-65, "Manual of Standard Practice for Detailing Reinforced Concrete" are generally applicable to reinforced masonry.

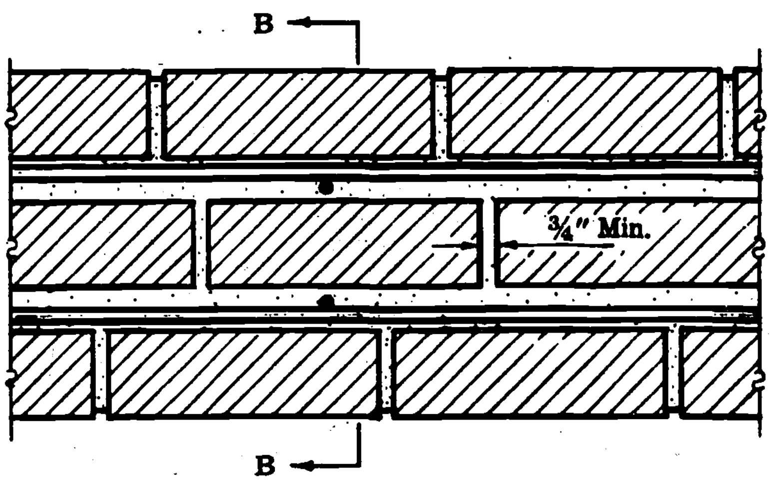
WALL SECTIONS



PLAN SECTION A-A

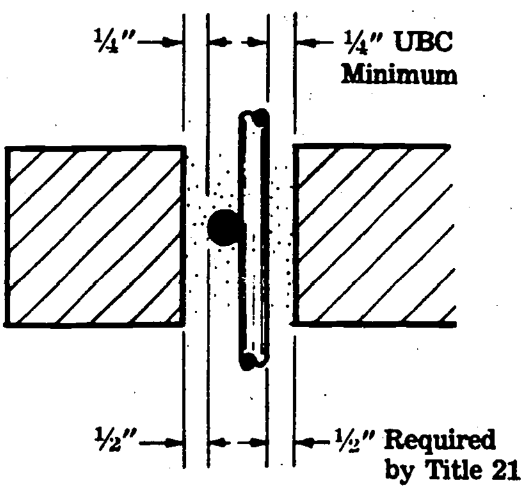


VERTICAL SECTION B-B



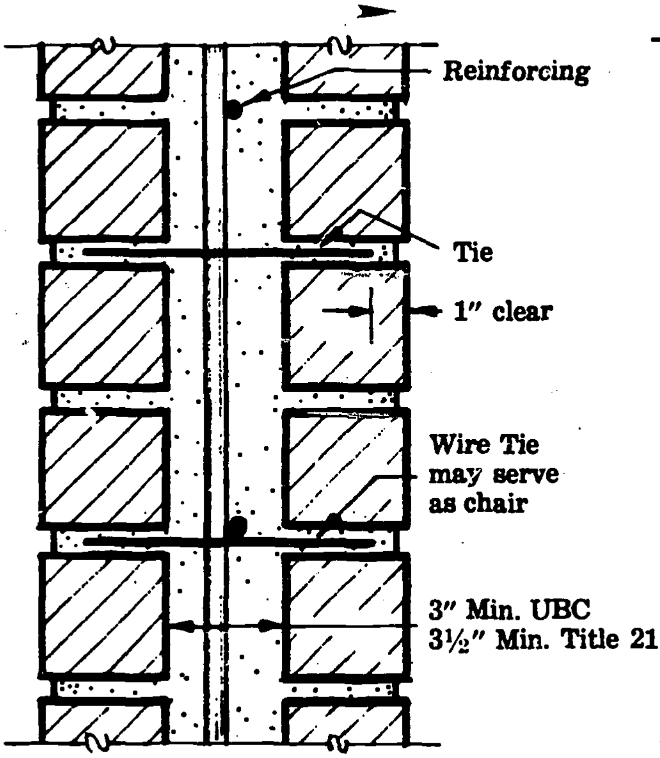
Both curtains of reinforcing steel may be in the vertical longitudinal joints as shown, if width permits

PLAN SECTION C-C

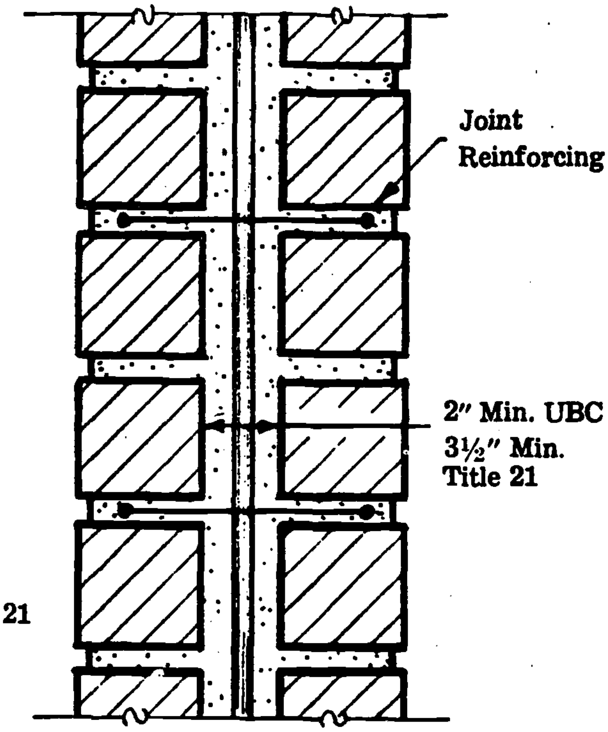


MINIMUM STEEL COVERAGE

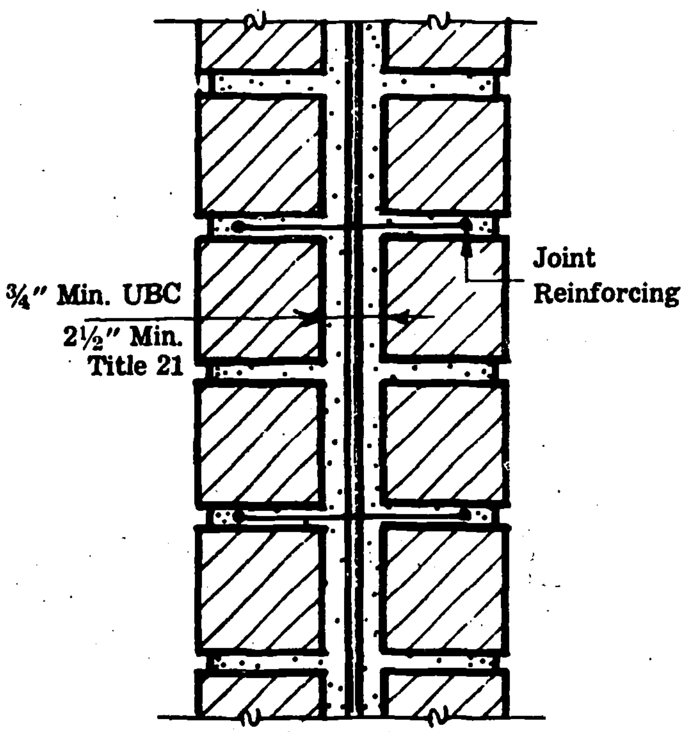
WALL SECTIONS



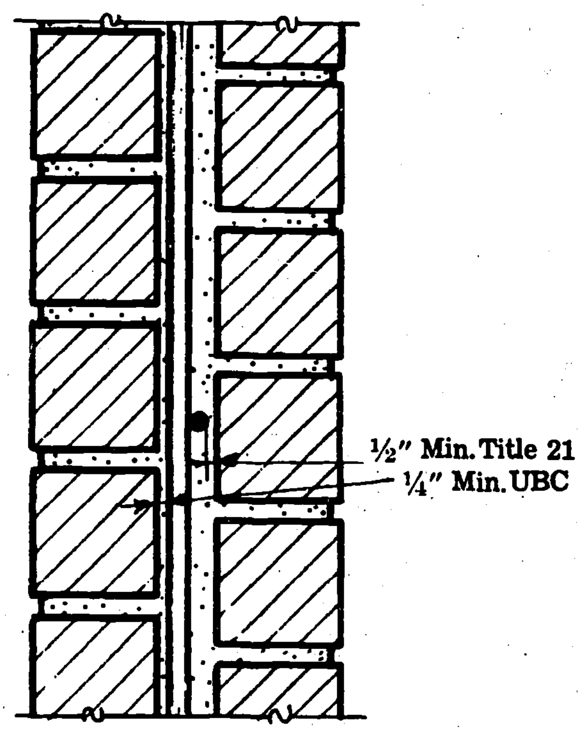
HIGH LIFT GROUTED WALL
WITH BAR REINFORCING



HIGH LIFT GROUTED WALL
WITH WIRE REINFORCING
(The joint reinforcing may
serve as required ties as well.)

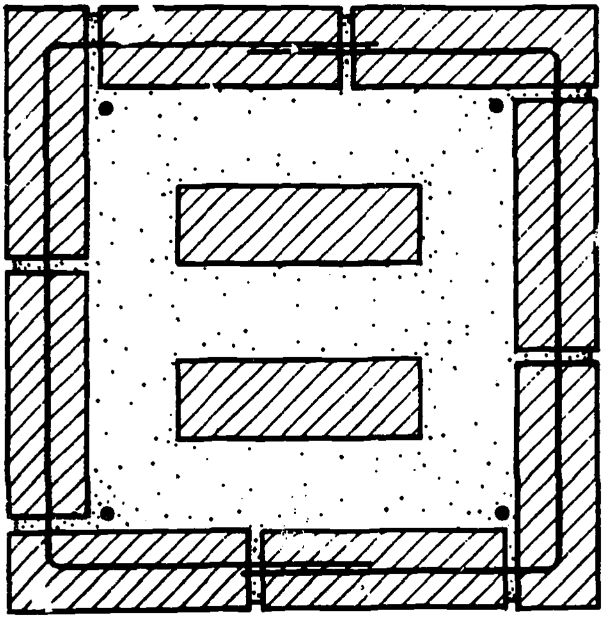


LOW LIFT GROUTED WALL
WITH WIRE REINFORCING

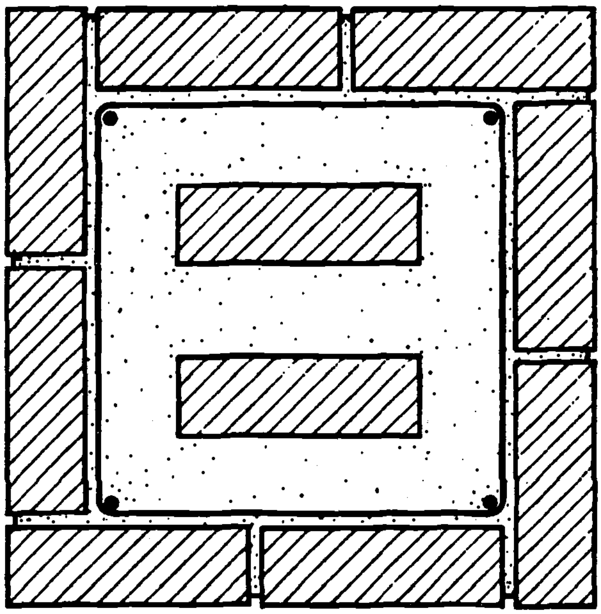


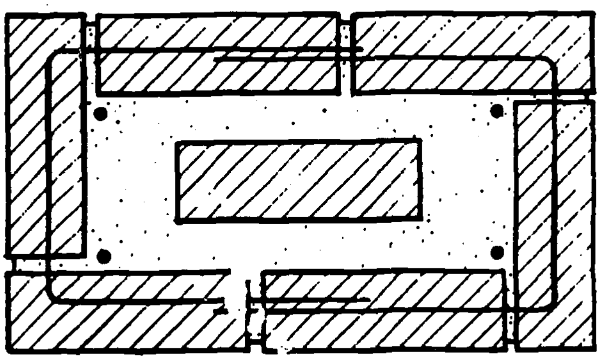
LOW LIFT GROUTED WALL
WITH BAR REINFORCING

BRICK COLUMNS

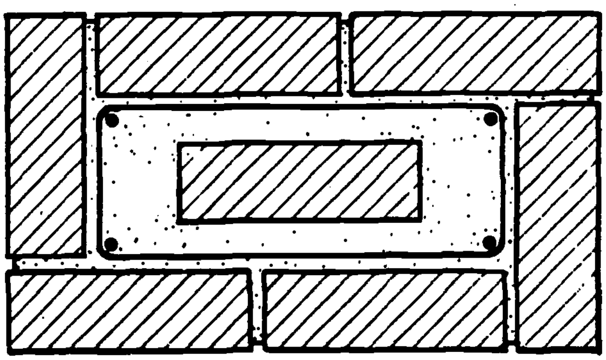


Alternate placement of ties.



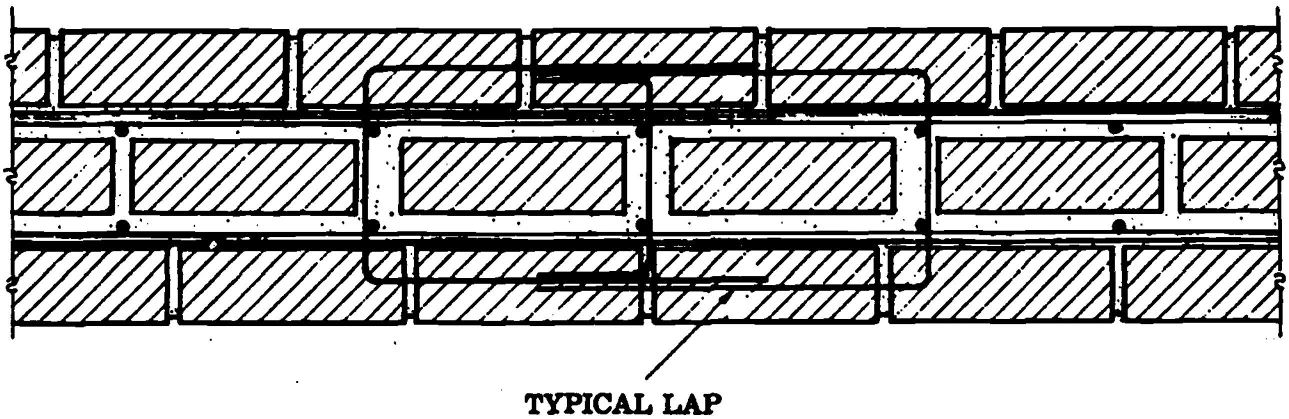


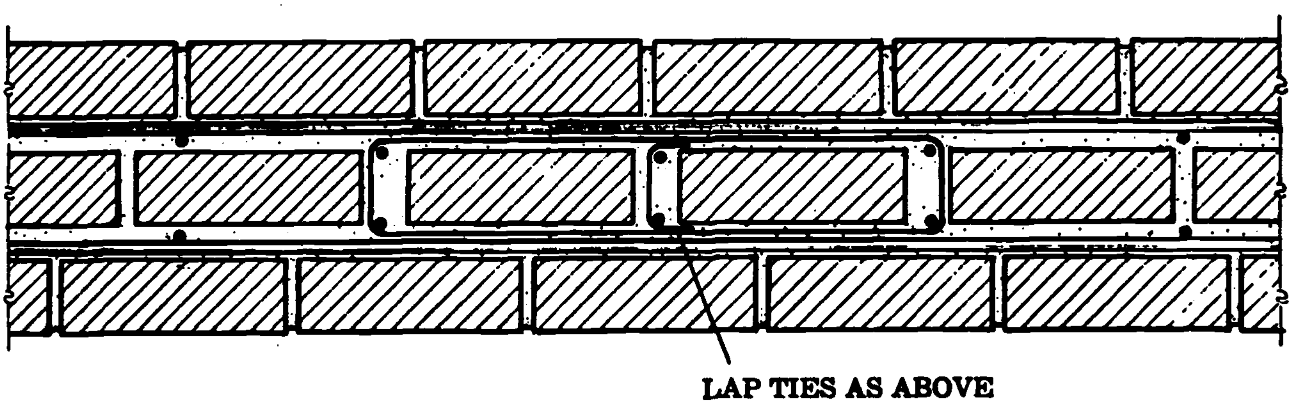
Alternate placement of ties.

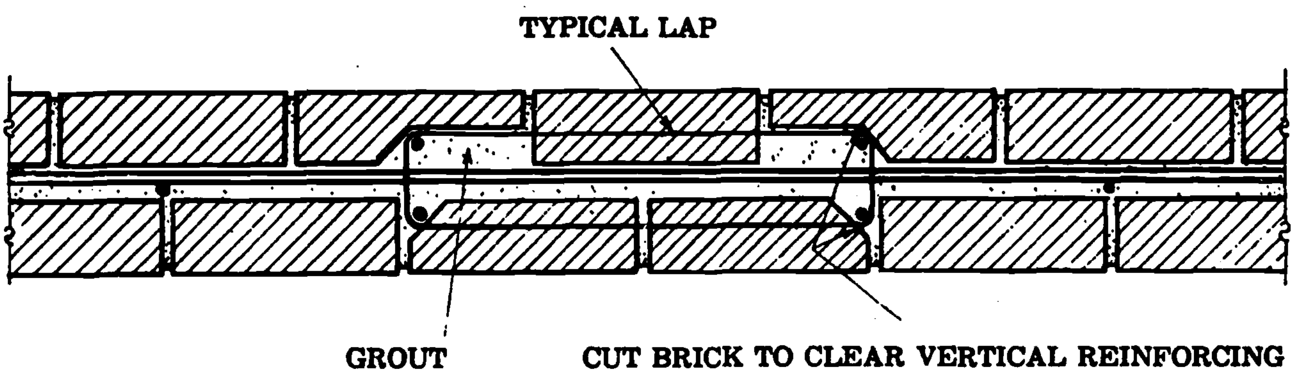


Note that the ties may be either in the bed joint or against the vertical steel. It is to be noted also that straight laps are shown, with no hooks.

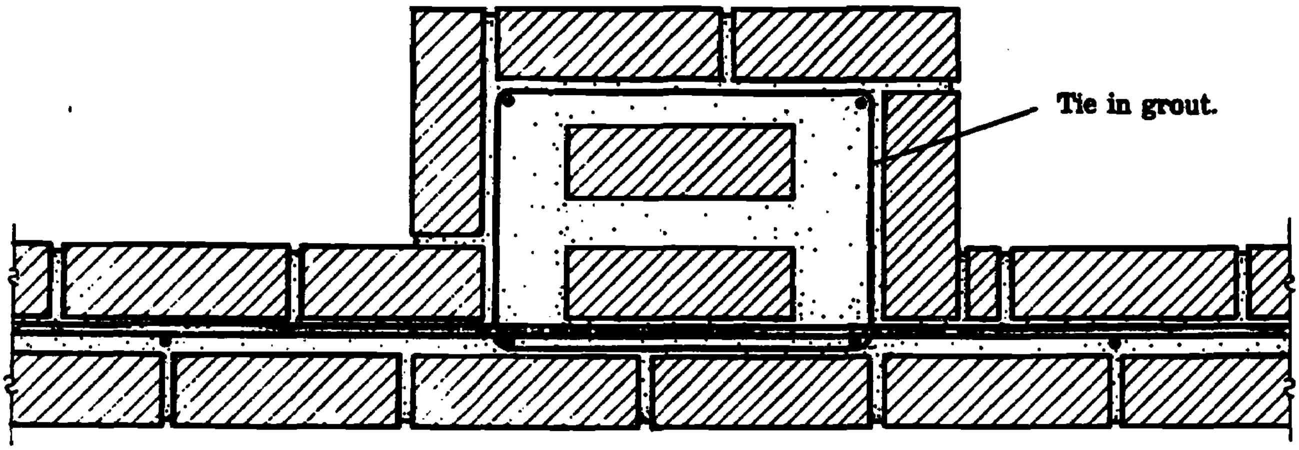
WALL COLUMNS

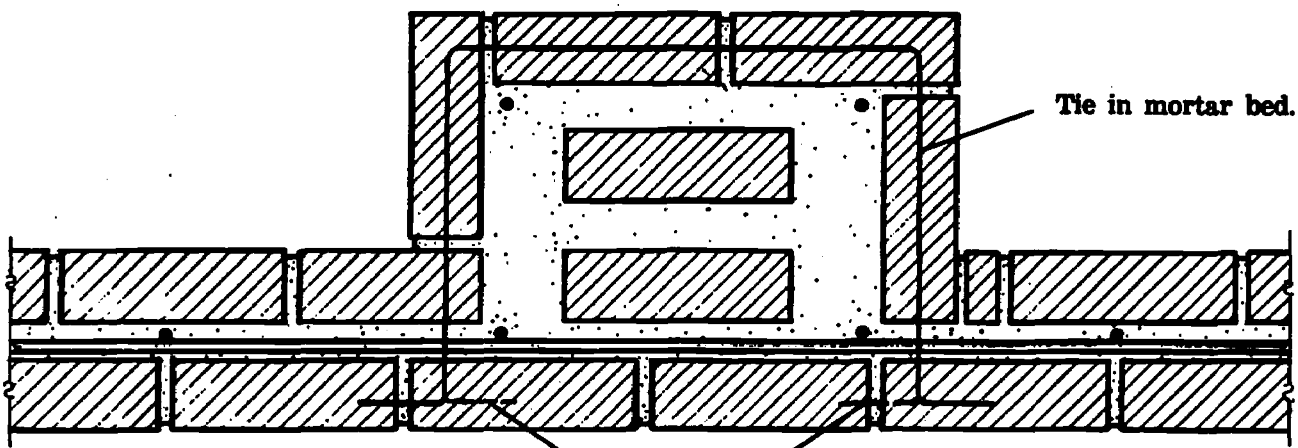






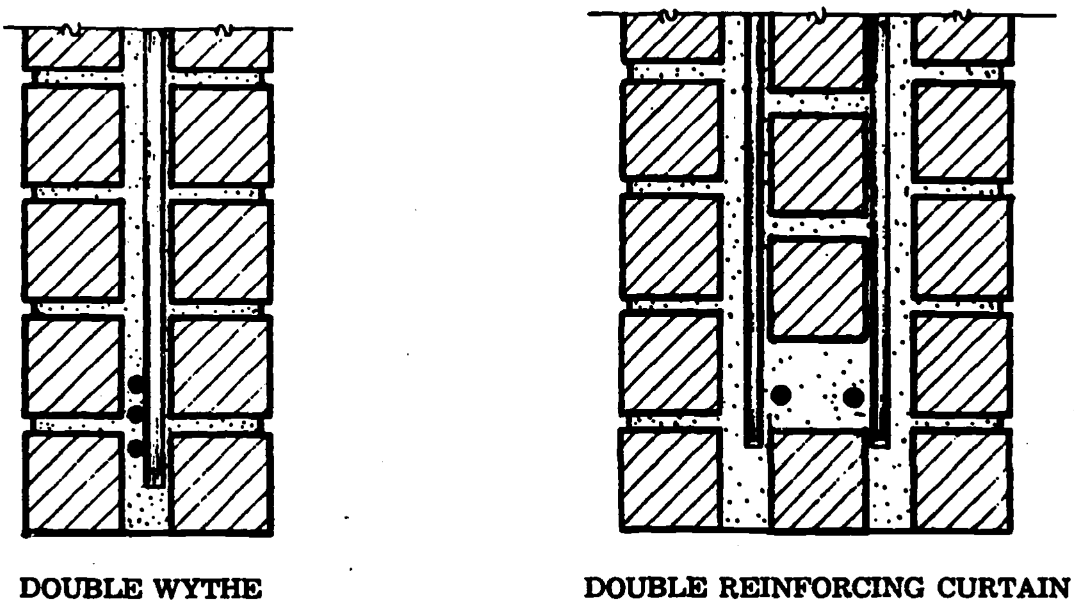
PILASTERS





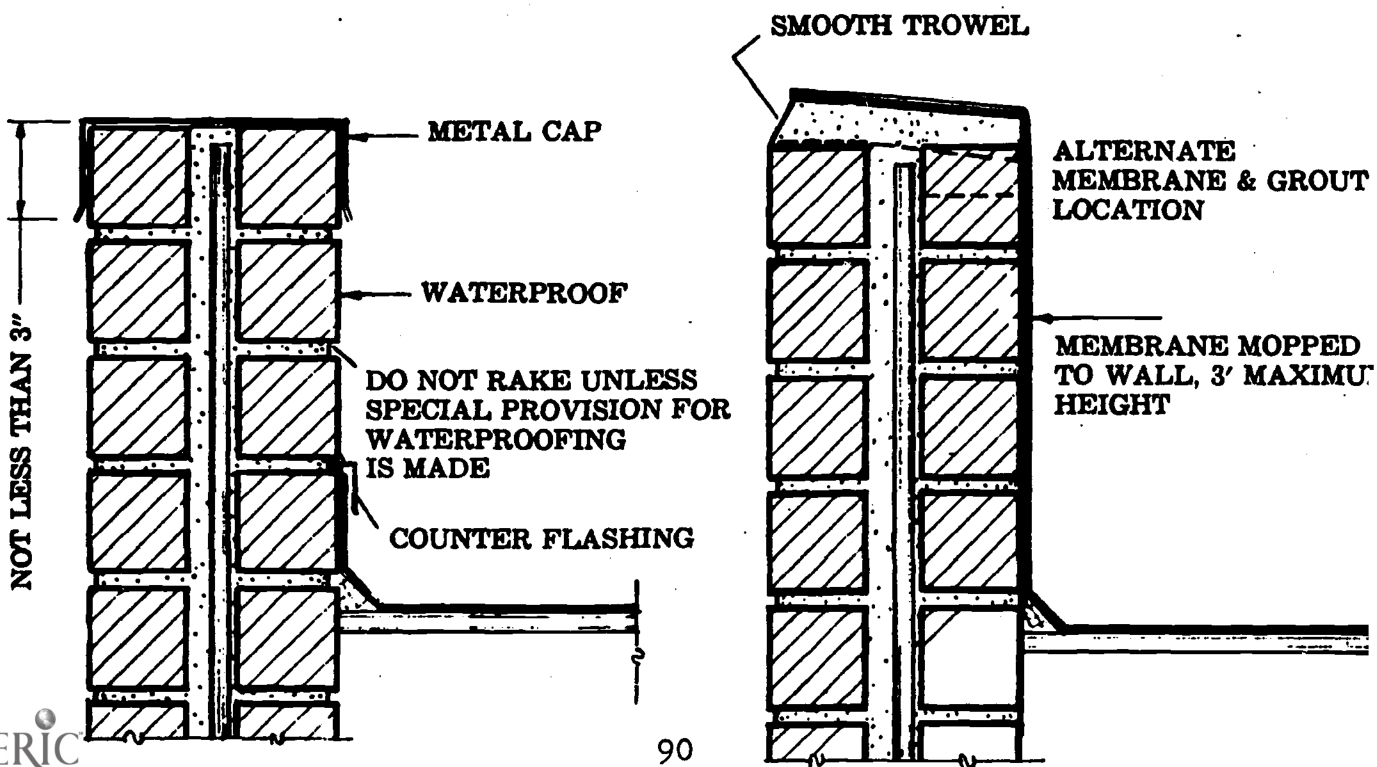
WALL PILASTERS SHOWING ALTERNATE TIE LOCATION

LINTELS

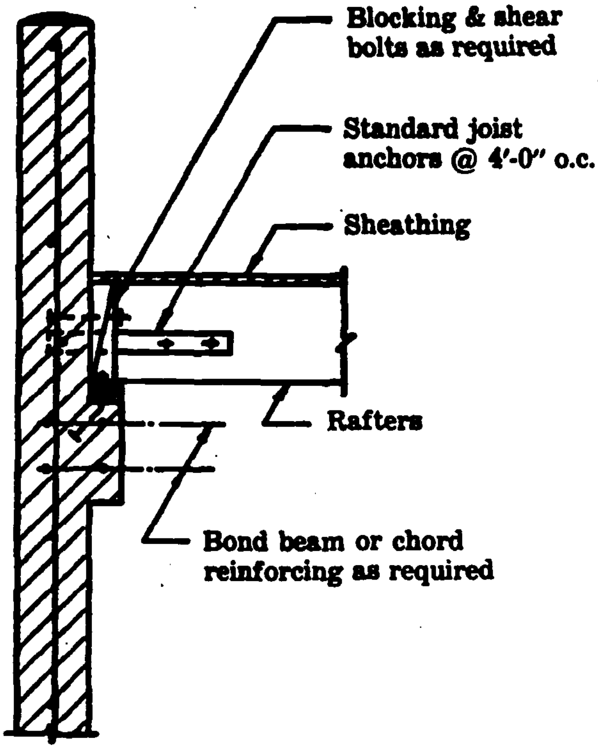


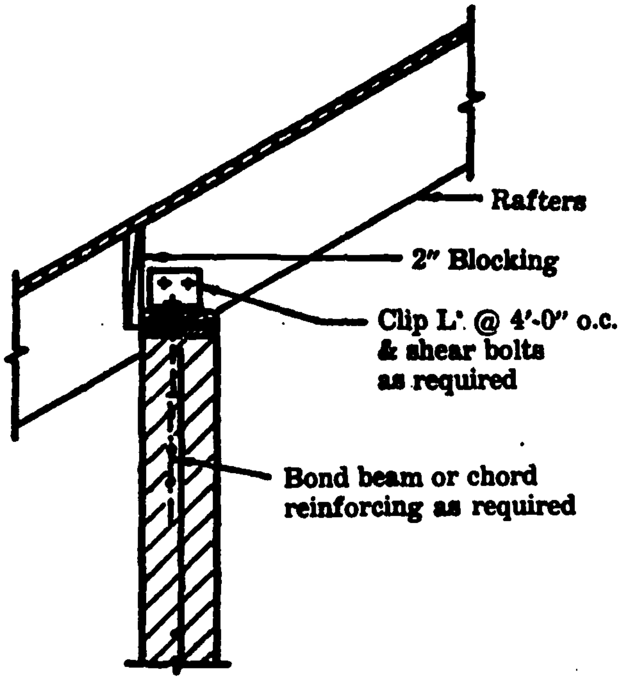
REINFORCING STEEL ARRANGEMENT FOR LINTEL BEAMS
IN TWO WYTHE AND THREE WYTHE THICK WALLS

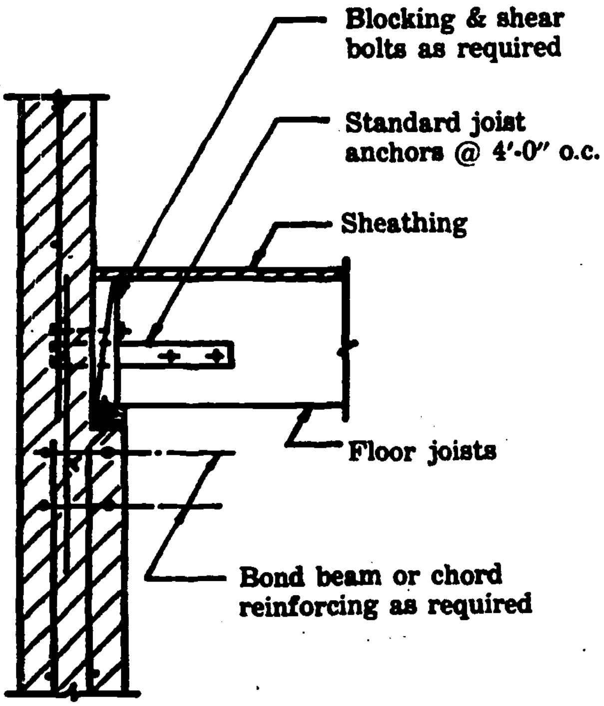
PARAPETS

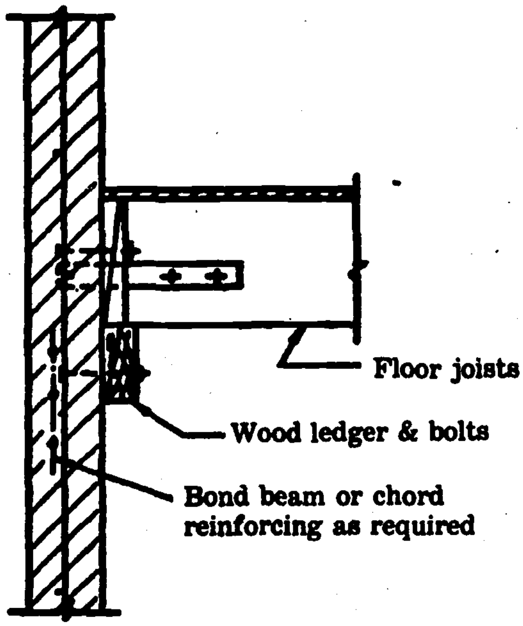


WOOD DETAILS



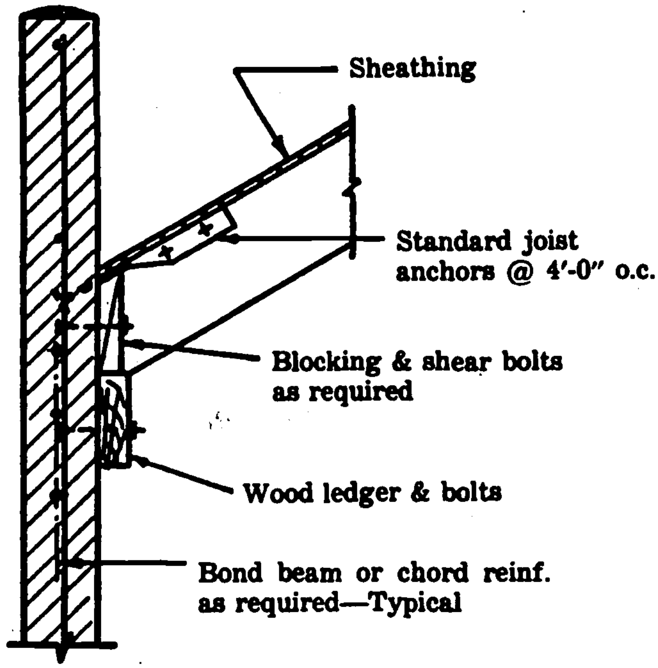


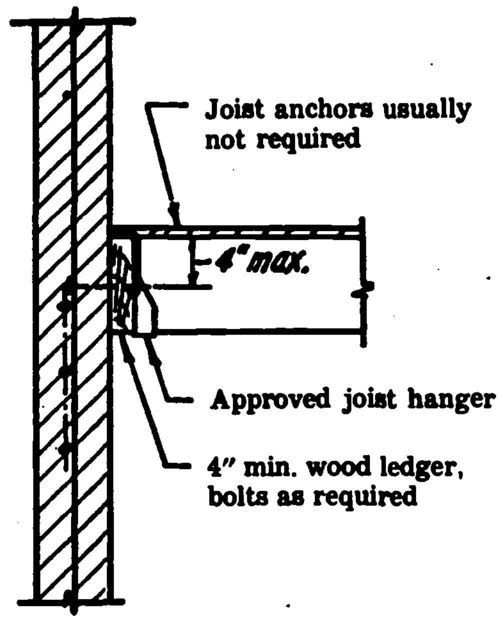


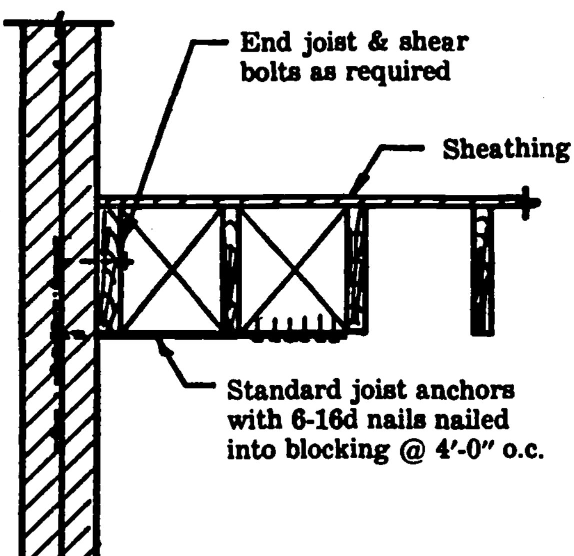


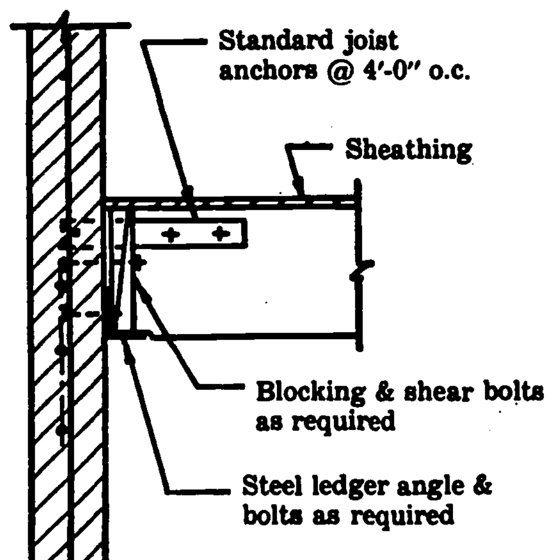
Clip angles may be used instead of standard joist anchors.
Check governing code.

WOOD DETAILS



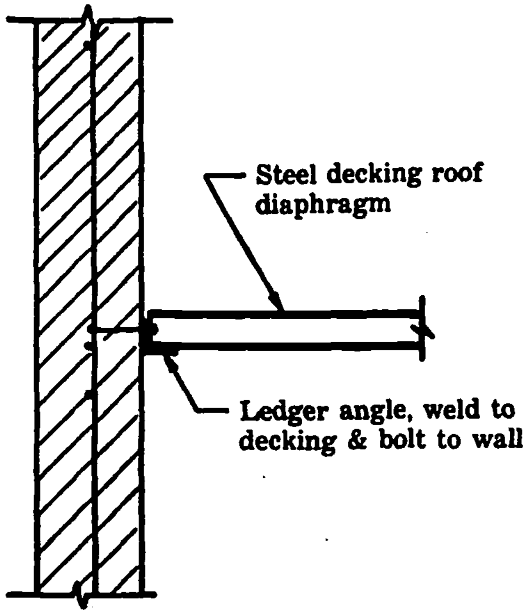




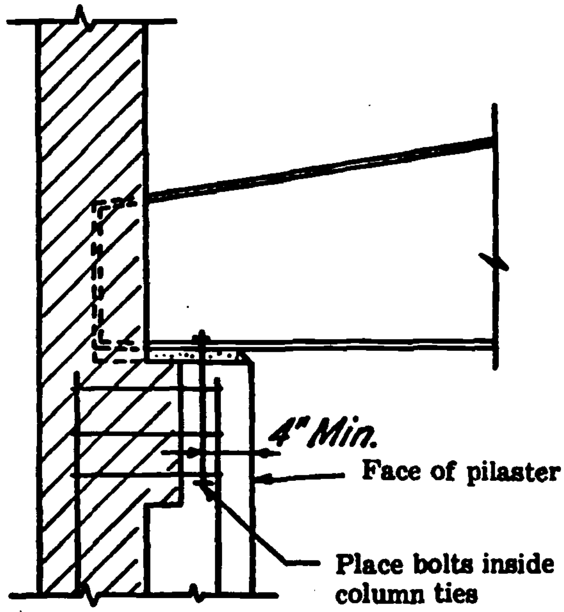


Clip angles may be used instead of standard joist anchors. Check governing code.

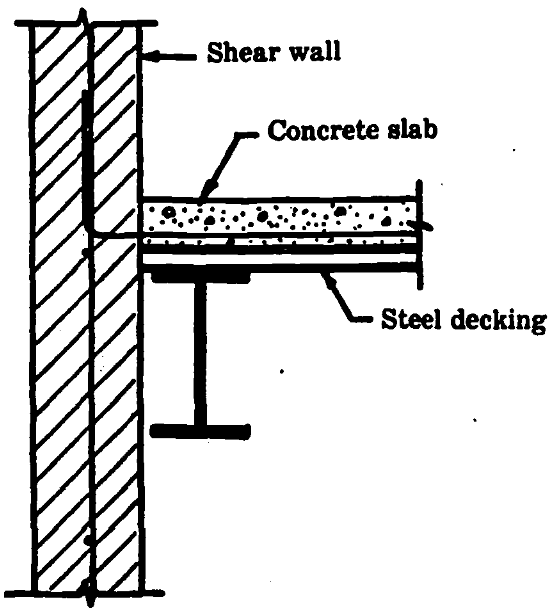
STEEL DETAILS



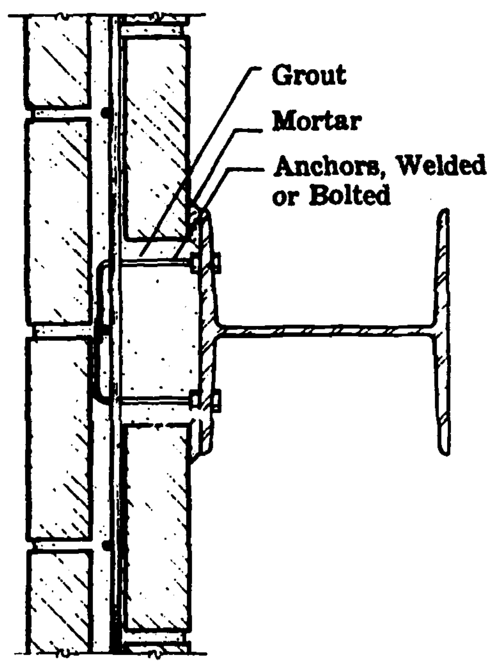
Shear or curtain wall



Shear wall

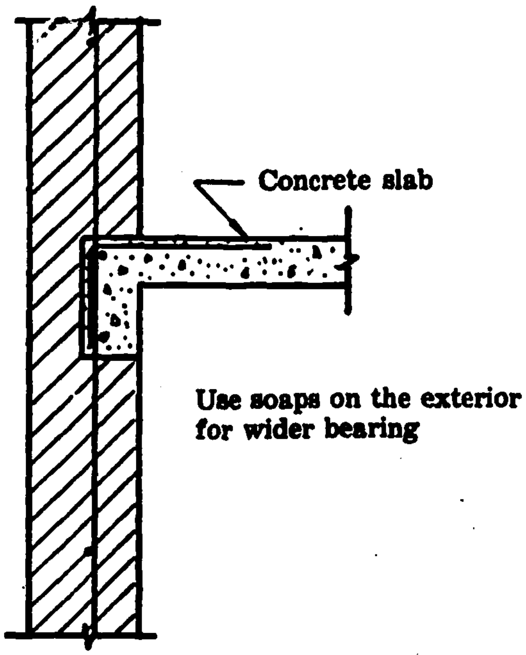


Shear wall

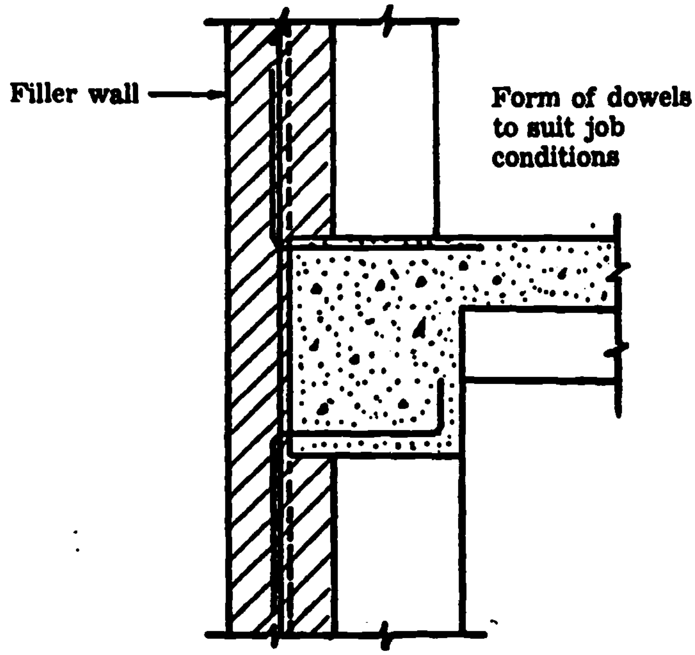


WALL AT STEEL COLUMN

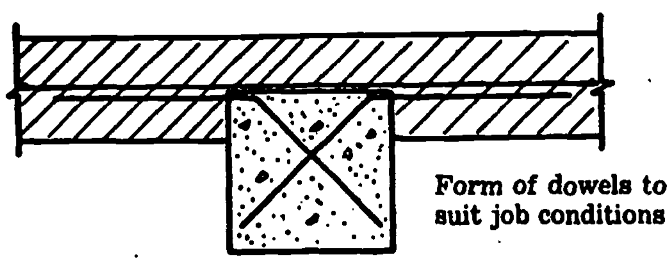
CONCRETE DETAILS



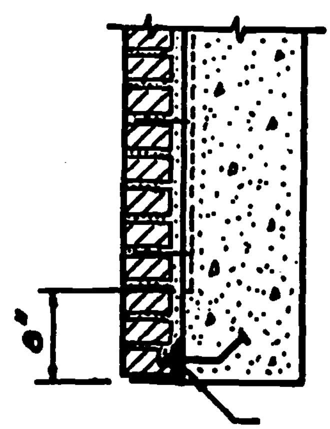
Bearing wall



Filler wall with
concrete frame

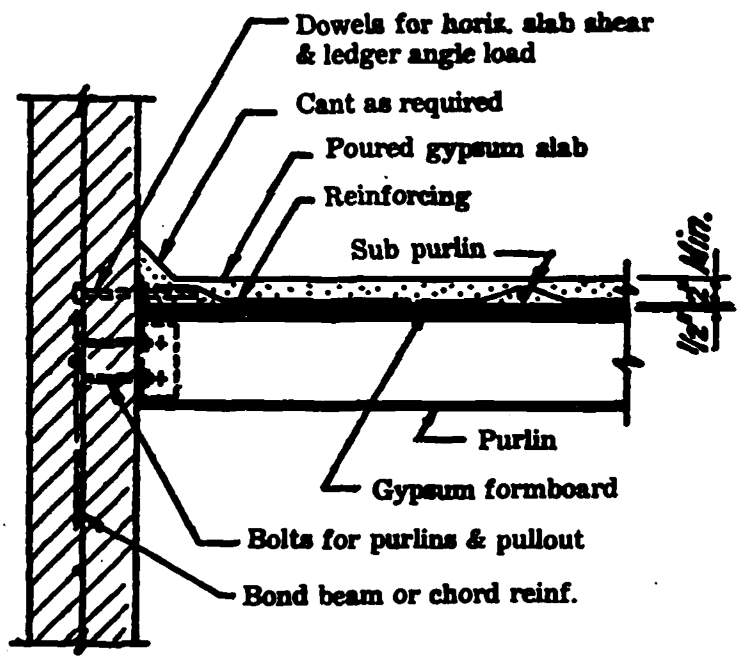


Column

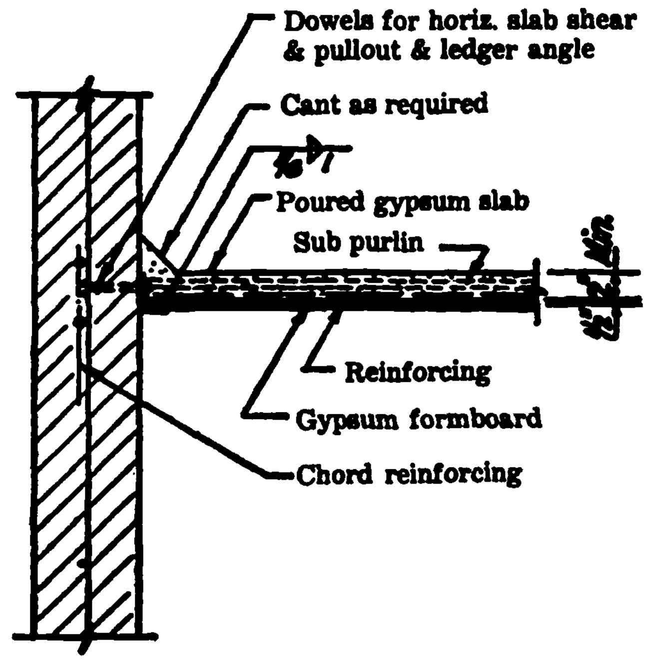


Veneer
concrete spandrel

GYPSUM ROOF DIAPHRAGM

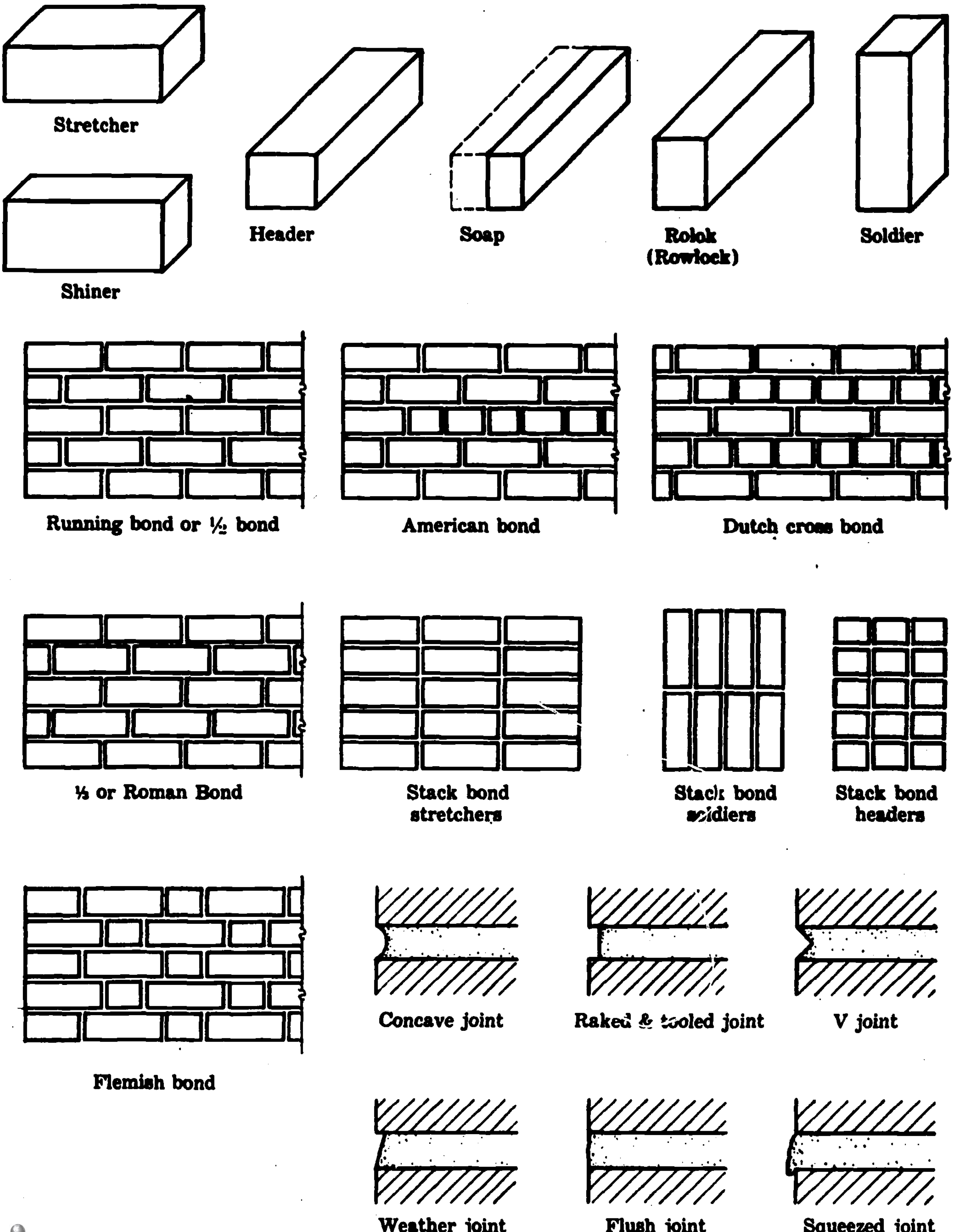


Sub purlin parallel
to wall



Sub purlin perpendicular
to wall

BRICK PATTERNS AND JOINERY



BASIC CONCRETE MASONRY UNITS

CONCRETE MASONRY UNITS

The Concrete Masonry Association has selected the concrete masonry units which are shown on pages 99 100, 101 & 102 as basic standards. Units are grouped according to the wall thickness in which they are used. Special details (page 102) show pilaster blocks in reference to their position in the wall. Architectural Feature Units are shown on page 103.

Dimensions

Common practice in describing masonry units is to give the width first, the height second, and the length last, followed by descriptive names. For example an 8x4x16 Standard Block is 8" wide, 4" high and 16" long. These sizes are in modular dimensions and actual sizes are 3/8" less.

All pertinent dimensions and minimum shell thicknesses are shown. Rather than repeat dimensions for each unit, the Standard Block in each group is dimensioned, and these dimensions apply to other units in the group. Where there are variations in the units applicable dimensions are shown for the individual unit.

ARCHITECTURAL FEATURE UNITS (See page 103)

The ever changing pattern of the concrete masonry feature unit is the result of demands by the Architect for flexibility in scale and design. As the Architectural features of buildings change, the materials used must also change.

Some of the categories of Architectural Feature Units are outlined as follows:

Cap or Paving Units

Cap or paving units are manufactured in a variety of sizes. These are used as capping units for parapet and garden walls and are also used for stepping stones, patios, fireplaces, barbecues, veneering, etc. Many integral colors are available. They may be used both structurally and nonstructurally. When used in reinforced walls the reinforcing steel is generally laid in grout space between wythes.

Slumped Units

Slumped units are available in standard and special sizes and in a variety of colors. The widths vary with the amount of surface projection but the heights are held to specified dimensions. They are used to give special architectural effect both in structural and non-structural construction.

Split-Faced Units

Split-Faced units are manufactured in standard and special sizes and in a variety of textures and colors. The special feature of these units is the architectural appearance of one side. This makes possible a standard block texture on one side of the wall and a special stone-like texture on the exposed side.

Veneer Units

Veneer Units are manufactured in a multitude of colors and as many textures. They are non-structural and are laid against a structural back-up wall. The width is approximately $3\frac{1}{2}$ inches, but the height varies with the type. Any of the architectural units which have been mentioned and the standard 4" wide blocks can be used as veneers to give the effect which is desired by the designer.

Special Shaped Units

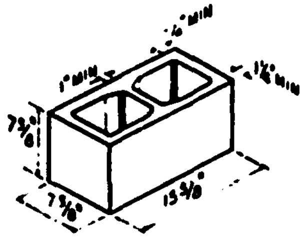
Concrete Masonry Units are flexible in that they are capable of being adapted, modified or molded; responsive to changing conditions. Special Shaped Units provide this flexibility. These are available for structural and non-structural purposes and in standard and supplementary sizes, including 12" high units and design face units.

Screen Blocks

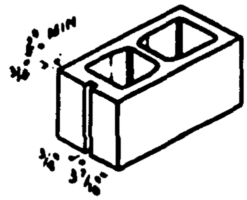
The newest member of the concrete masonry family is the most dramatic. Screen wall units are manufactured in standard face and sculptured designs. The sizes have a range to meet nearly every decorative need from a 4x4x4 to the giant 16" square. These units in addition to complete fire safety are used in areas to screen out street noises as well as augment the already efficient insulating qualities of the other concrete masonry. The natural gray color can be painted to blend or complement other materials and colors.

8" WIDE WALL

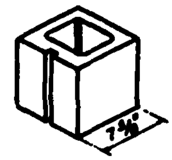
8" HIGH UNITS



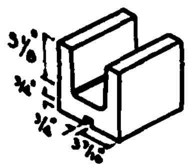
8 x 8 x 16
Standard



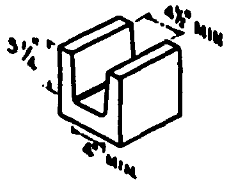
8 x 8 x 16
Sash



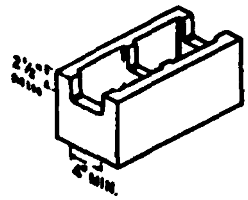
8 x 8 x 8
Half Sash



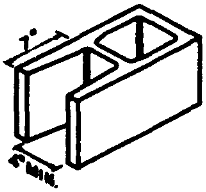
8 x 8 x 8
Sash lintel



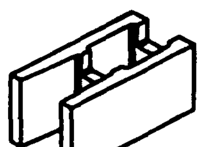
8 x 8 x 8
Standard lintel



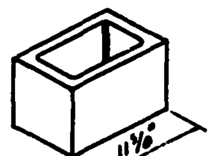
8 x 8 x 16
Bond beam



8 x 8 x 16
Open end

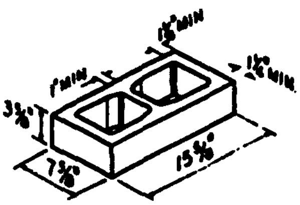


8 x 8 x 16
Open end
Bond beam

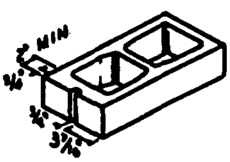


8 x 8 x 12
Three quarter

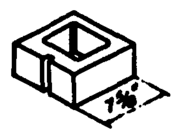
4" HIGH UNITS



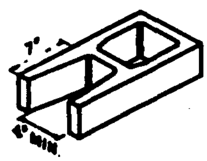
8 x 4 x 16
Standard



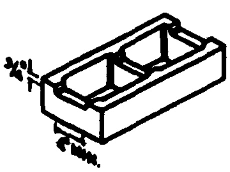
8 x 4 x 16
Sash



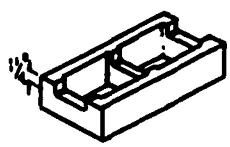
8 x 4 x 8
Half sash



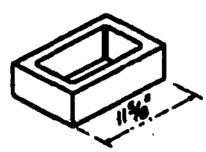
8 x 4 x 16
Open end



8 x 4 x 16
Channel



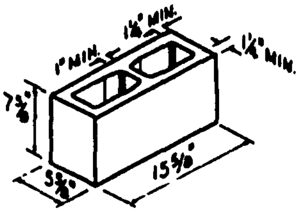
8 x 4 x 16
Bond beam



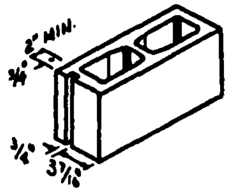
8 x 4 x 12
Three quarter

6" WIDE WALL

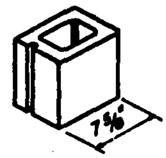
8" HIGH UNITS



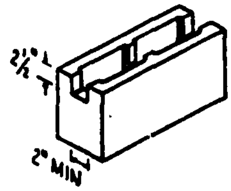
6 x 8 x 16
Standard



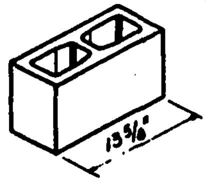
6 x 8 x 16
Sash



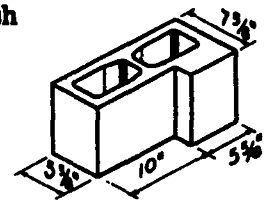
6 x 8 x 8
Half sash



6 x 8 x 16
Bond beam

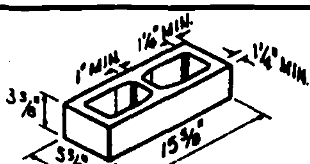


6 x 8 x 14
Corner

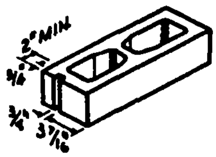


6 x 8 x 16*
Offset corner

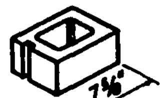
4" HIGH UNITS



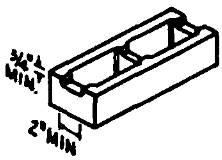
6 x 4 x 16
Standard



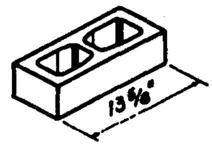
6 x 4 x 16
Sash



6 x 4 x 8
Half sash



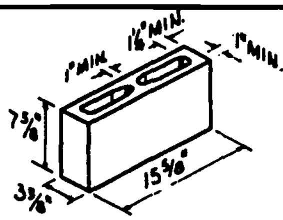
6 x 4 x 16
Channel



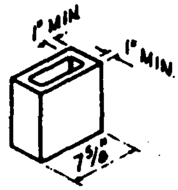
6 x 4 x 14
Corner

4" WIDE WALL

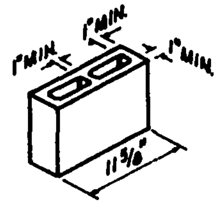
8" HIGH UNITS



4 x 8 x 16
Standard

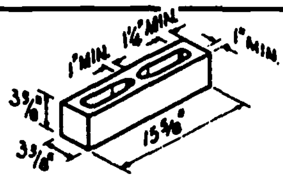


4 x 8 x 8
Half

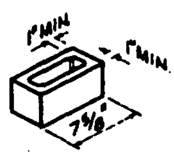


4 x 8 x 12
Corner

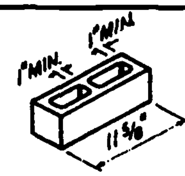
4" HIGH UNITS



4 x 4 x 16
Standard



4 x 4 x 8
Half

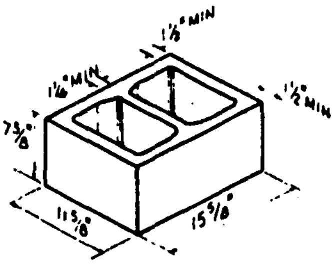


4 x 4 x 12
Corner

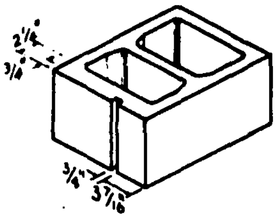
*(On special order)

12" WIDE WALL

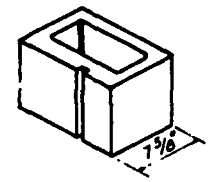
8" HIGH UNITS



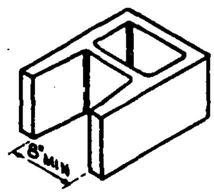
12 x 8 x 16
Standard



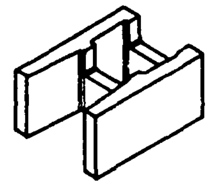
12 x 8 x 16
Sash



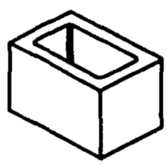
12 x 8 x 8
Half sash



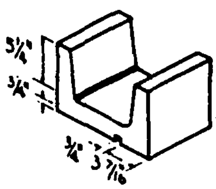
12 x 8 x 16
Open end



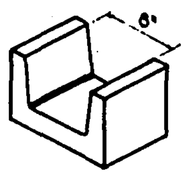
12 x 8 x 16
Open end bond beam



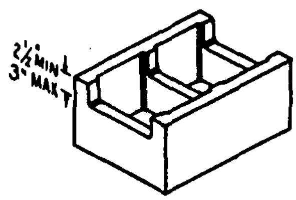
12 x 8 x 8
Half



12 x 8 x 8
Sash
lintel

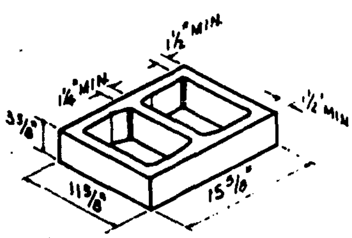


12 x 8 x 8
Standard
lintel

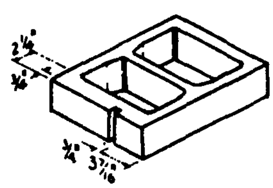


12 x 8 x 16
Bond beam

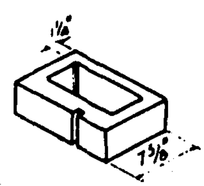
4" HIGH UNITS



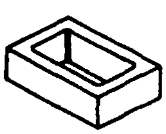
12 x 4 x 16
Standard



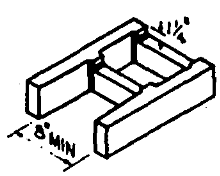
12 x 4 x 16
Sash



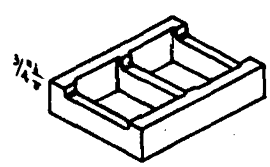
12 x 4 x 8
Half sash



12 x 4 x 8
Half



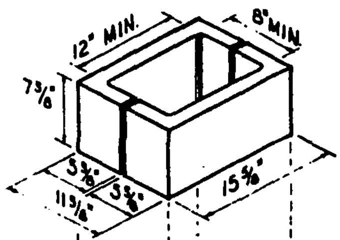
12 x 4 x 16
Open end bond beam



12 x 4 x 16
Channel

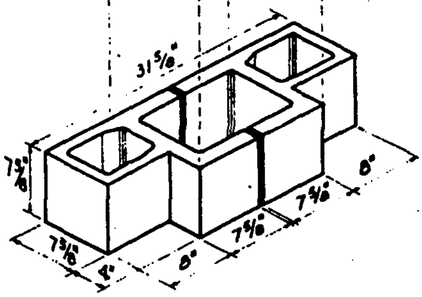
PILASTERS FOR 8" WIDE WALL

12 x 8 x 16
Alternate
pilaster



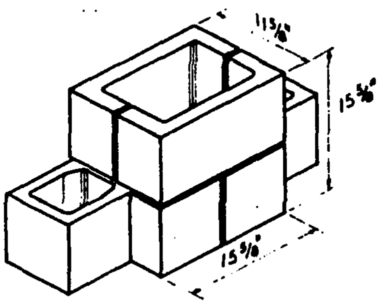
used with

12 x 8 x 16
Open
pilaster

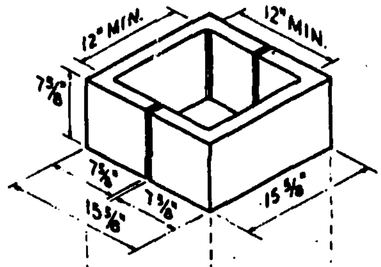


Equals

12 x 16 x 16
Pilaster

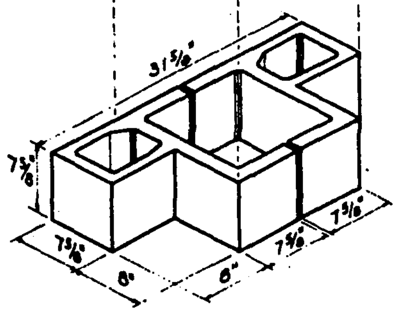


16 x 8 x 16
Alternate
pilaster



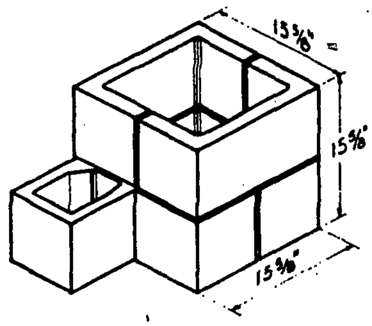
used with

16 x 8 x 16
Open
pilaster

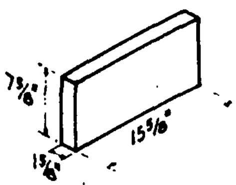


Equals

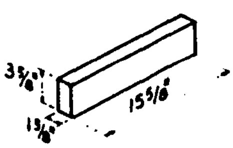
16 x 16 x 16
Pilaster



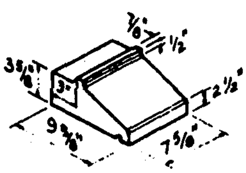
ACCESSORY BLOCKS



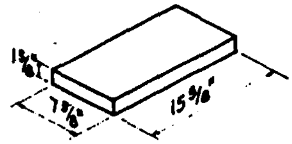
2 x 8 x 16
Veneer



2 x 4 x 16
Veneer

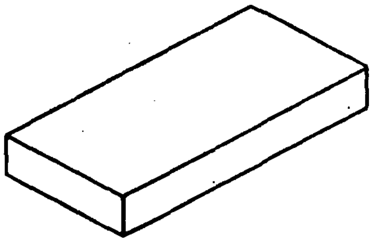


10 x 4 x 8
Sill

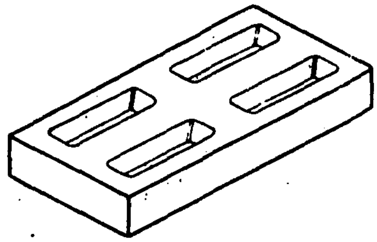


8 x 2 x 16
Cap

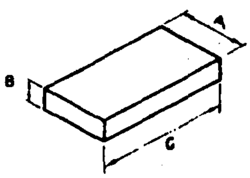
ARCHITECTURAL FEATURE UNITS



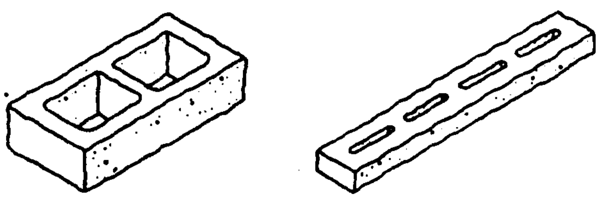
Cap or paving unit



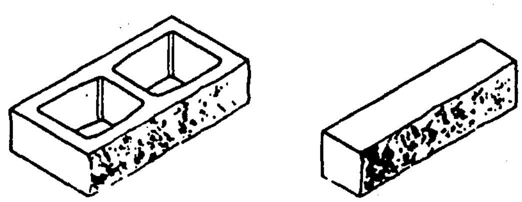
Cap or paving unit (reversed)
some units are manufactured
with indentations on underside
which acts as a mortar key.



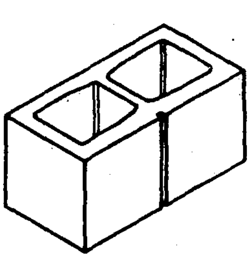
CAP OR PAVING UNIT SIZES															
MODULAR								STANDARD							
UNIT NO.	A	B	C	UNIT NO.	A	B	C	UNIT NO.	A	B	C	UNIT NO.	A	B	C
1 M	3⅝"	2¼"	7⅝"	8 M	7⅝"	2¼"	15⅝"	1 S	3¾"	2¼"	8"	8 S	8"	2¼"	16½"
2 M	3⅝"	2¼"	15⅝"	9 M	9¼"	2¼"	15⅝"	2 S	3¾"	2¼"	16½"	9 S	10"	2¼"	16½"
3 M	5⅝"	2¼"	7⅝"	10 M	11⅝"	2¼"	15⅝"	3 S	5⅞"	2¼"	8"	10 S	12¼"	2¼"	16½"
4 M	5⅝"	2¼"	15⅝"	11 M	15⅝"	2¼"	15⅝"	4 S	5⅞"	2¼"	16½"	11 S	3¾"	1⅝"	16½"
5 M	7⅝"	2¼"	7⅝"	12 M	3⅝"	1⅝"	15⅝"	5 S	8"	2¼"	8"	12 S	5⅝"	1⅝"	16½"
6 M	7⅝"	2¼"	9¼"	13 M	5⅝"	1⅝"	15⅝"	6 S	8"	2¼"	10"	13 S	8"	1⅝"	16½"
7 M	7⅝"	2¼"	11⅝"	14 M	7⅝"	1⅝"	15⅝"	7 S	8"	2¼"	12¼"	14 S	12¼"	1⅝"	16½"



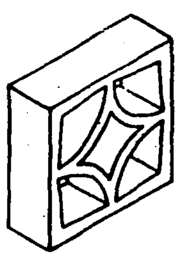
Slumped



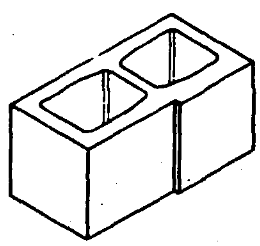
Split faced



Center scored



Screen block



Offset face

TYPICAL ASSEMBLY AND LAYOUT

ASSEMBLY AND LAYOUT

Modular Dimensions (pages 106 - 109)

The width, height, and length of all concrete masonry units ends in 5/8". For example, a block 15 5/8" long plus 3/8" mortar joints equals 16" length. The object of modular coordination is to take advantage of economy of having all building materials apply to 4" increments including masonry materials.

Modular dimension lines are from the center of a joint to the center of a joint as shown on the corner and jamb details, pages 106-109. For this reason, the thickness of one mortar joint should be subtracted from the modular dimension to give the exact length. For opening dimensions the thickness of one mortar joint should be added to the modular dimensions to get exact opening dimensions.

For simplicity it is usually advisable to use modular dimensioning for the floor plan and block layout plan as all fractions are eliminated. Exact dimensions can be used but they will be in fractions of an inch.

Actual dimensions should be considered when dimensioning the foundation plan (pages 106 and 107); however, modular dimensions may also be used.

8" and 4" Modular Layout (pages 106 & 107)

For design simplicity and economy of construction plan dimensions should be determined by using multiples of 8" (8" modular dimension). This not only means a total wall length should be a multiple of 8" but walls between openings as well as openings themselves should conform to this 8" modular dimension.

Sometimes it is impractical to adhere to the 8" module and a 4" module must be used. Masonry opening widths of 1'-8", 3'-0" and 3'-8" and wall space between openings of 2'-4" shown on page 107 require 12" long blocks (three quarter unit). The use of this unit has little effect on wall patterns and presents no great problems with cell alignment.

Corner Details (pages 108 & 109)

Corners involve variations from the regular wall layout system and in some cases involve variations in dimensional layout. (Pages 108 and 109 illustrate the common methods of corner layout.)

Because the 6" wide and 12" wide units used in combination with other widths are not adaptable to the 8" modular standard, some cutting of units at the corners is necessary as shown on detail 5 and detail 8, page 109. Likewise 8" modular lengths are not possible to be developed in details 2, 3 and 5, pages 108 & 109.

Residence (pages 110-111, 114-116)

A foundation plan (page 110) and the block layout plan (page 111) illustrate the development for a typical residence. The floor plan for the residence is shown on page 114, elevations are shown on page 115 and sections are shown on page 116.

A block layout plan (page 111) showing the blocks at the first course is important as it not only relieves dimensions from the floor plan but will save block laying time for the mason.

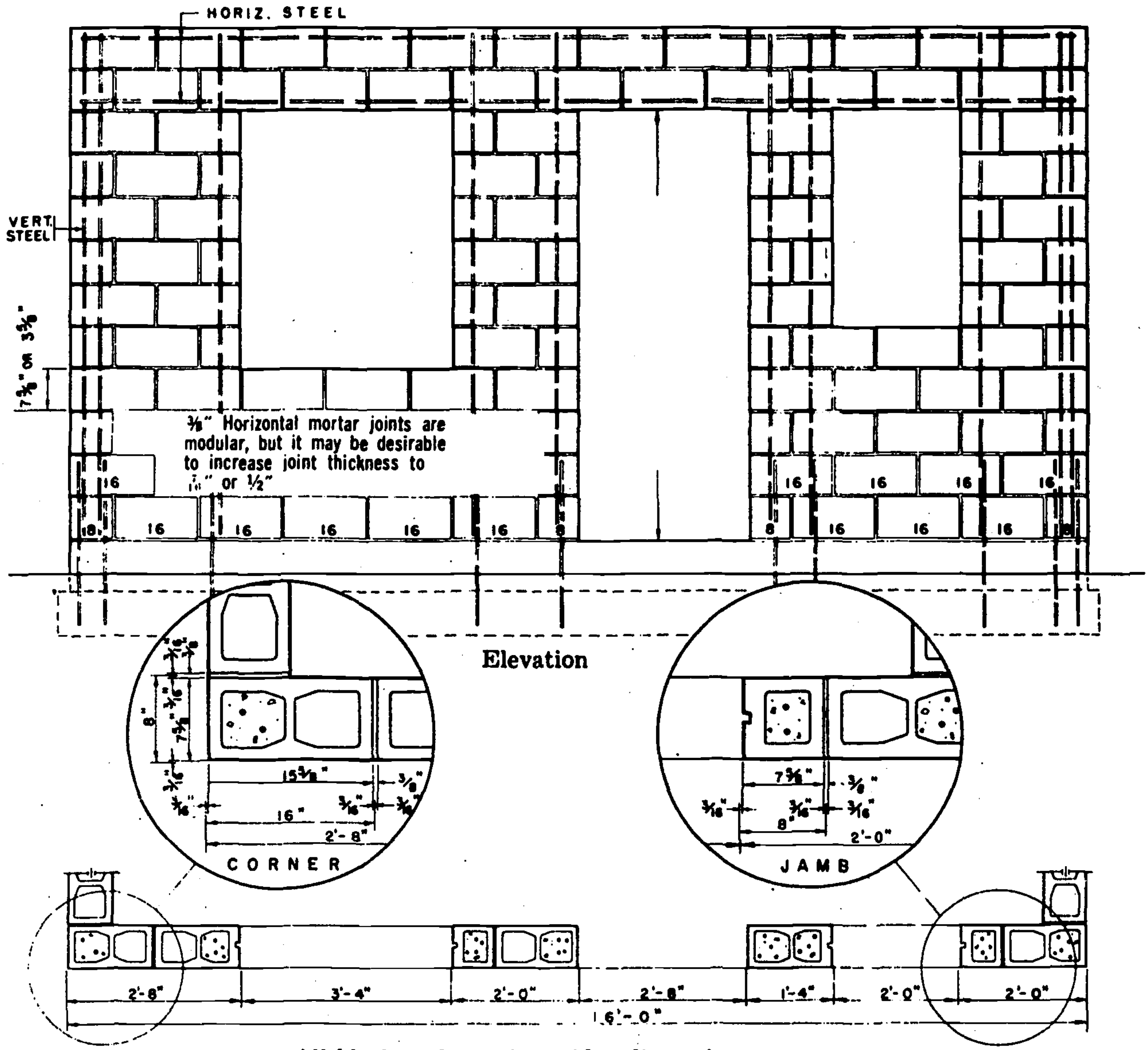
Vertical core alignment is important as steel reinforcement must be continuous from the foundation to the bond beam and the layout plan should provide for this alignment. Also, when the first block course is properly laid the rest of the block laying time is greatly simplified.

Foundation plan (page 110) should accurately locate the dowel steel. Other items such as plumbing and electrical which are to be installed with or before concrete work can be shown on the foundation plan or this work can be properly noted and referred to other drawings which will show their location

Dimension Tables (page 112)

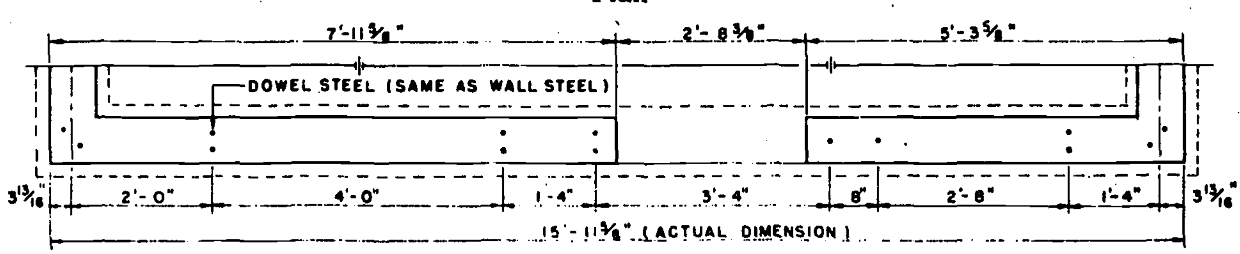
Dimension Tables will prove to be of great value to the architect or designer and for the estimator of block materials.

8" MODULAR LAYOUT DETAILS



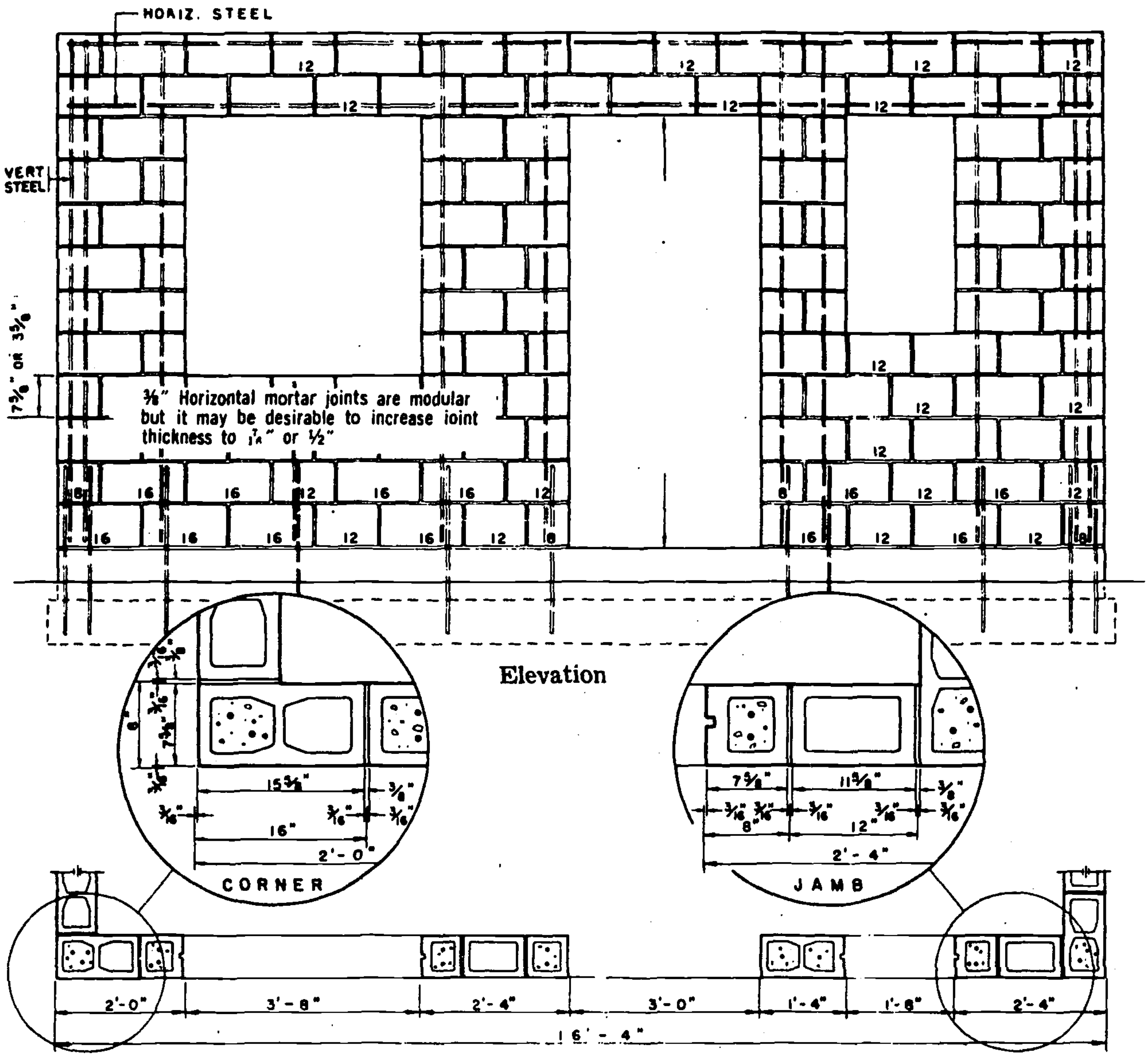
All block and opening width dimensions are multiples of 8" (8" modular dimensions)

Plan



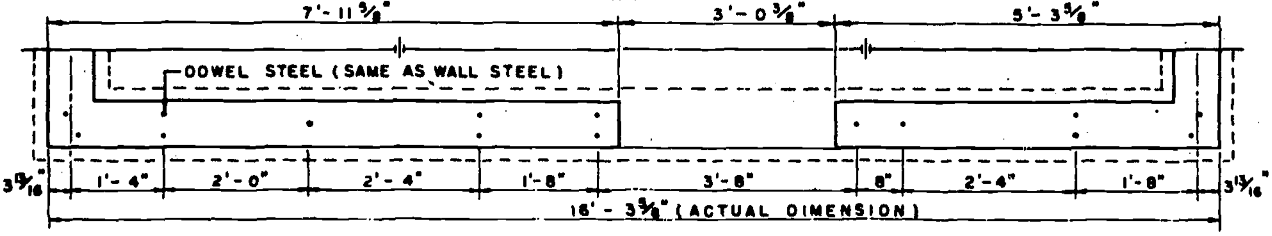
Foundation plan

4" MODULAR LAYOUT DETAILS



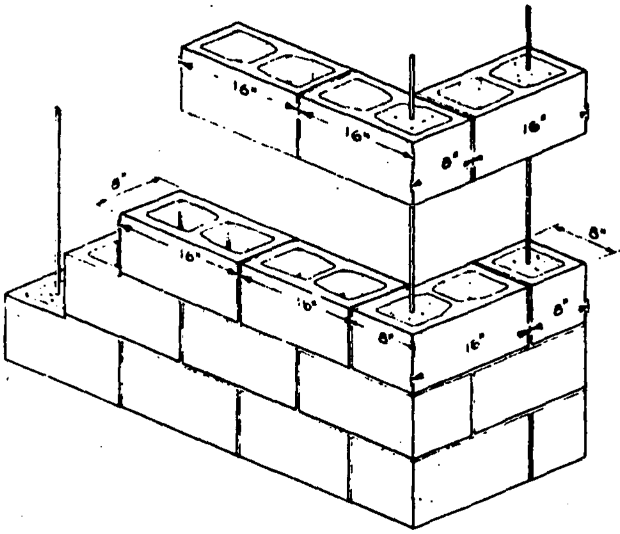
ALL BLOCK AND OPENING WIDTH DIMENSIONS ARE MULTIPLES OF 4" (4" MODULAR DIMENSIONS) — MASONRY OPENING DOOR WIDTH DIMENSION (3'-0") AND MASONRY OPENING WINDOW WIDTH DIMENSION (1'-8" AND 3'-8") REQUIRE USE OF 12" BLOCK (4" MODULE)

Plan

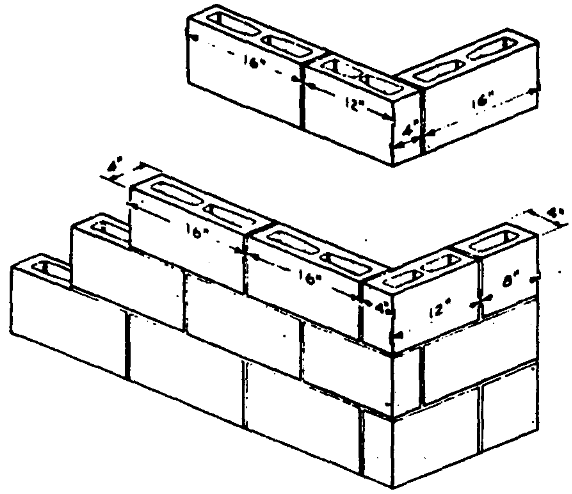


Foundation plan

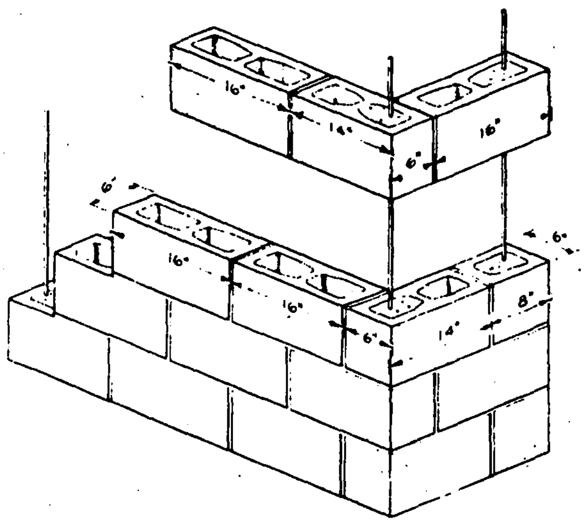
CORNER DETAILS



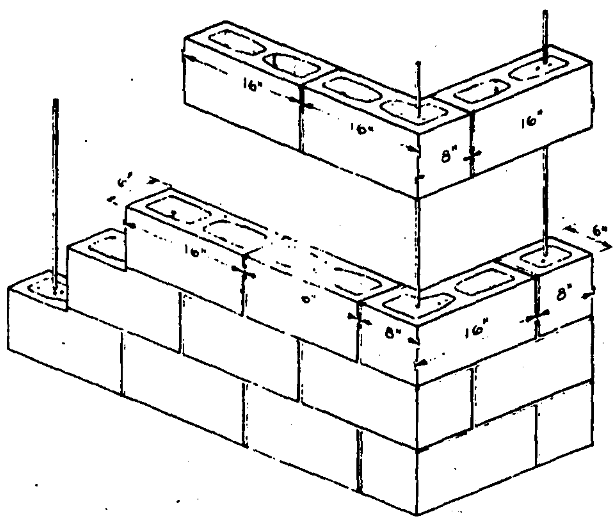
(1) 8″ wall to 8″ wall



(2) 4″ wall to 4″ wall

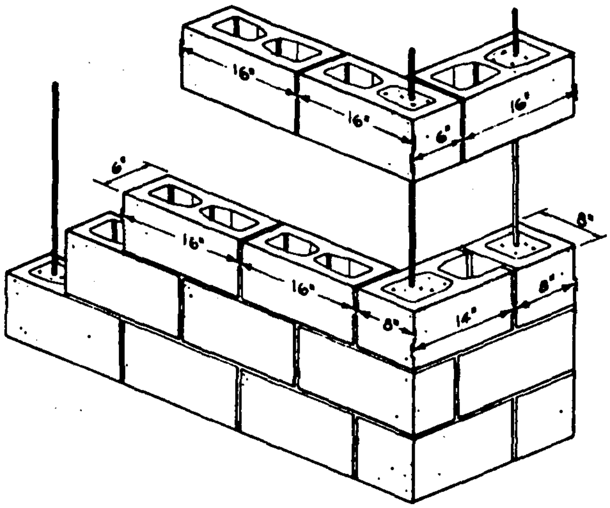


(3) 6″ wall to 6″ wall

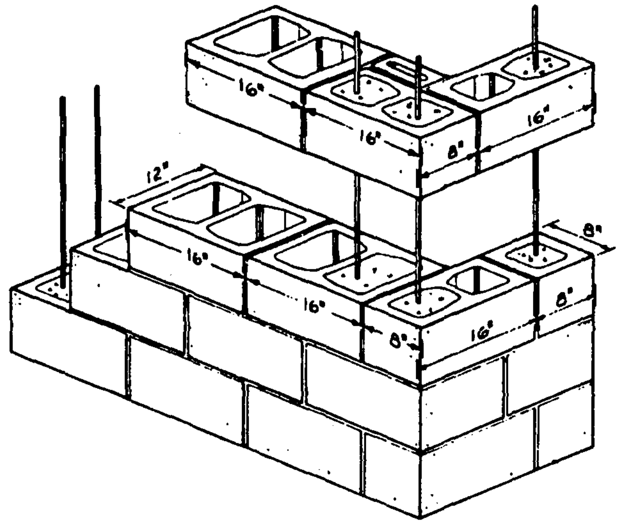


(4) 6″ wall to 6″ wall

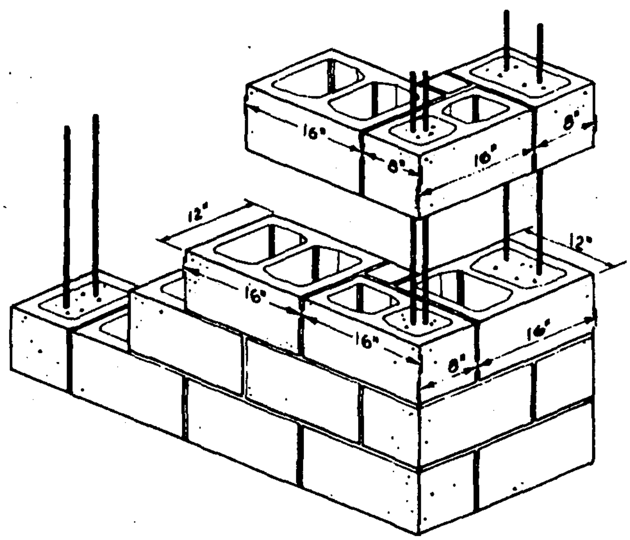
CORNER DETAILS



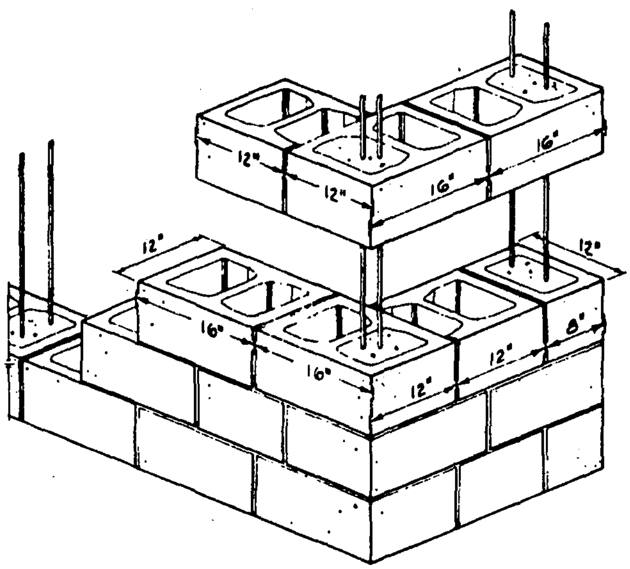
(5) 6″ wall to 8″ wall



(6) 12″ wall to 8″ wall

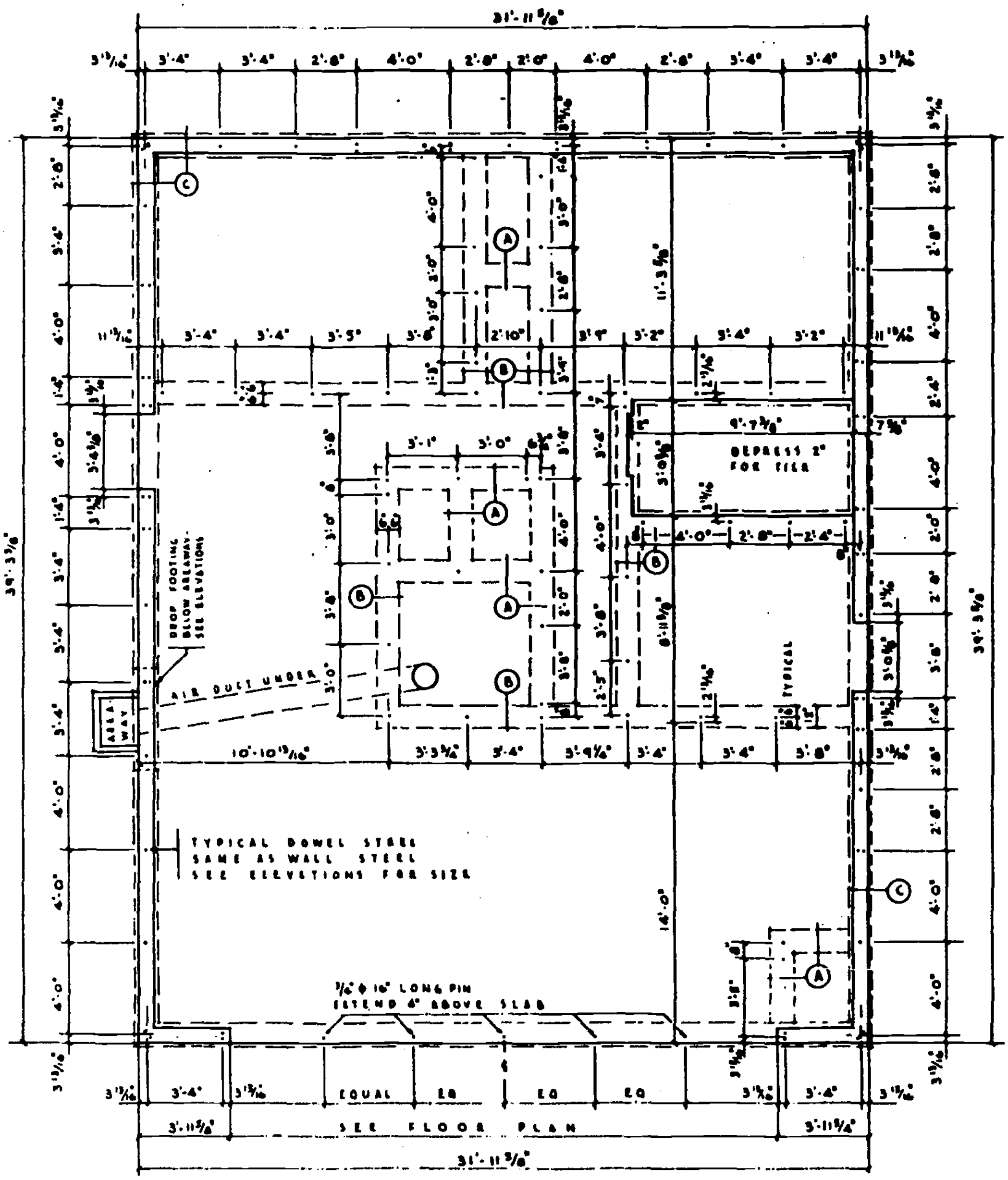


(7) 12″ wall to 12″ wall



(8) 12″ wall to 12″ wall

RESIDENCE — FOUNDATION PLAN



FOUNDATION PLAN

scale ½" = 1'-0"

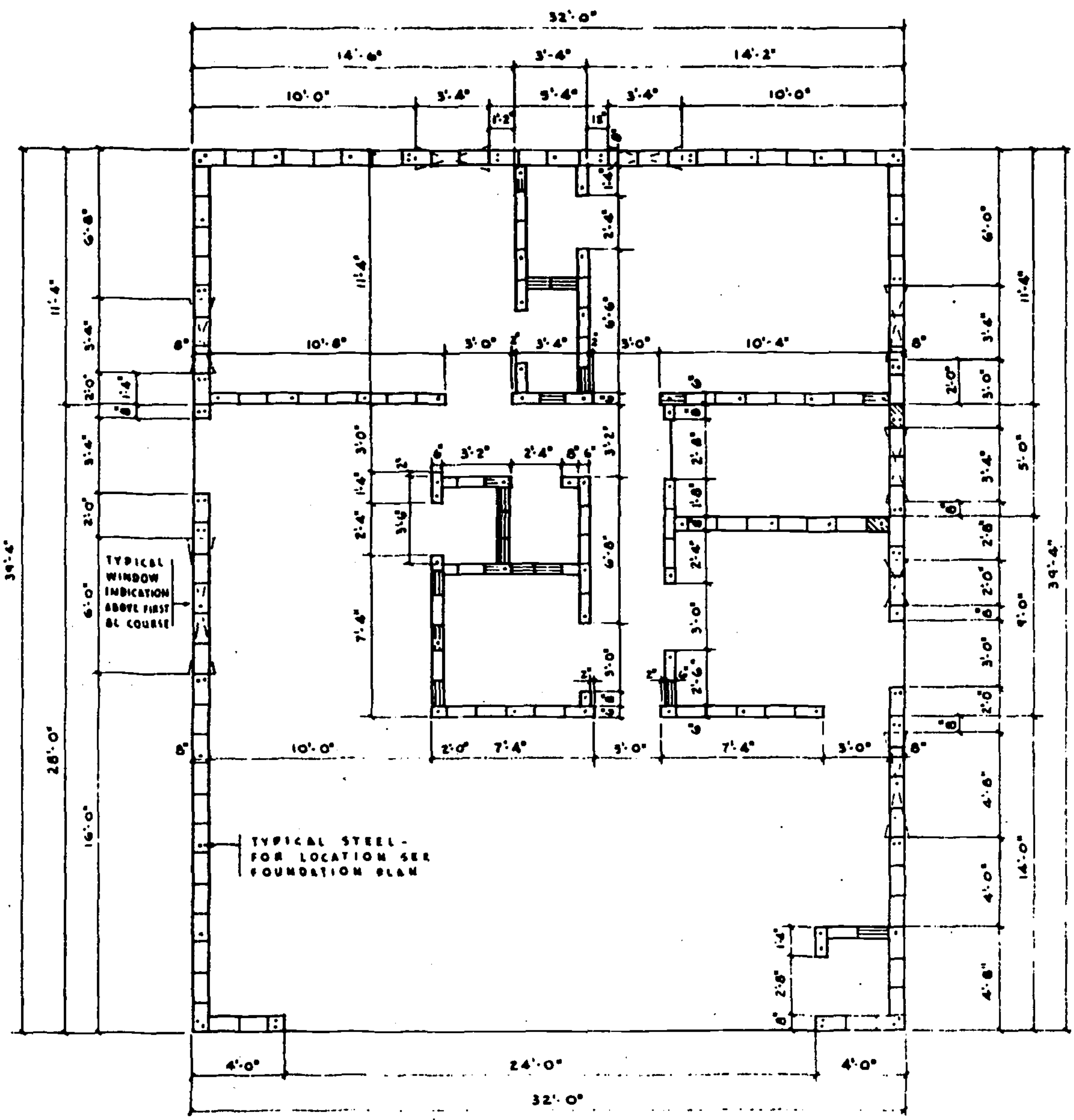
(A)—Non-bearing interior footing
See detail 5 page 113

(B)—Bearing interior footing
See detail 5 page 113

(C)—Exterior footing
Similar to detail 5 page 113

Note—
For conduit locations
see floor plan—
For plumbing locations
see floor plan—
Block layout plan—page 111
Floor plan—page 114
Elevations—page 115
Sections—page 116

RESIDENCE — BLOCK LAYOUT PLAN



PLAN AT FIRST BLOCK COURSE

scale 1/8" = 1'-0"

- 16" long block
- 8" long block
- 14" long block
- 12" long block

Foundation plan—page 110
Floor plan—page 114
Elevations—page 115
Sections—page 116

DIMENSION TABLES

TABLE A (MODULAR)
3/8" HORIZ. AND VERTICAL MORTAR JOINTS

LENGTH	NO. 16" LONG BLOCKS	HEIGHT	NO 4" HIGH BLOCKS	NO 8" HIGH BLOCKS
0'-8"	1/2	0'-4"	1	
1'-4"	1	0'-8"	2	1
2'-0"	1 1/2	1'-0"	3	
2'-8"	2	1'-4"	4	2
3'-4"	2 1/2	1'-8"	5	
4'-0"	3	2'-0"	6	3
4'-8"	3 1/2	2'-4"	7	
5'-4"	4	2'-8"	8	4
6'-0"	4 1/2	3'-0"	9	
6'-8"	5	3'-4"	10	5
7'-4"	5 1/2	3'-8"	11	
8'-0"	6	4'-0"	12	6
8'-8"	6 1/2	4'-4"	13	
9'-4"	7	4'-8"	14	7
10'-0"	7 1/2	5'-0"	15	
10'-8"	8	5'-4"	16	8
11'-4"	8 1/2	5'-8"	17	
12'-0"	9	6'-0"	18	9
12'-8"	9 1/2	6'-4"	19	
13'-4"	10	6'-8"	20	10
14'-0"	10 1/2	7'-0"	21	
14'-8"	11	7'-4"	22	11
15'-4"	11 1/2	7'-8"	23	
16'-0"	12	8'-0"	24	12
16'-8"	12 1/2	8'-4"	25	
17'-4"	13	8'-8"	26	13
18'-0"	13 1/2	9'-0"	27	
18'-8"	14	9'-4"	28	14
19'-4"	14 1/2	9'-8"	29	
20'-0"	15	10'-0"	30	15
20'-8"	15 1/2	10'-4"	31	
21'-4"	16	10'-8"	32	16
22'-0"	16 1/2	11'-0"	33	
22'-8"	17	11'-4"	34	17
23'-4"	17 1/2	11'-8"	35	
24'-0"	18	12'-0"	36	18
24'-8"	18 1/2	12'-4"	37	
25'-4"	19	12'-8"	38	19
26'-0"	19 1/2	13'-0"	39	
26'-8"	20	13'-4"	40	20
27'-4"	20 1/2	13'-8"	41	
28'-0"	21	14'-0"	42	21
28'-8"	21 1/2	14'-4"	43	
29'-4"	22	14'-8"	44	22
30'-0"	22 1/2	15'-0"	45	
30'-8"	23	15'-4"	46	23
31'-4"	23 1/2	15'-8"	47	
32'-0"	24	16'-0"	48	24
32'-8"	24 1/2	16'-4"	49	
40'-0"	30	16'-8"	50	25
50'-0"	37 1/2	17'-0"	51	
60'-0"	45	17'-4"	52	26
70'-0"	52 1/2	17'-8"	53	
80'-0"	60	18'-0"	54	27
90'-0"	67 1/2	18'-4"	55	
100'-0"	75	18'-8"	56	28
200'-0"	150	19'-0"	57	
300'-0"	225	19'-4"	58	29
400'-0"	300	19'-8"	59	
500'-0"	375	20'-0"	60	30

TABLE B (NON-MODULAR)
7/16" HORIZONTAL MORTAR JOINT

HEIGHT	NO 4" HIGH BLOCKS	HEIGHT	NO 8" HIGH BLOCKS
0'-4 1/16"	1		
0'-8 1/8"	2	0'-8 1/16"	1
1'-0 3/16"	3		
1'-4 1/4"	4	1'-4 1/8"	2
1'-8 5/16"	5		
2'-0 3/8"	6	2'-0 3/16"	3
2'-4 7/16"	7		
2'-8 1/2"	8	2'-8 1/4"	4
3'-0 9/16"	9		
3'-4 5/8"	10	3'-4 5/16"	5
3'-8 11/16"	11		
4'-0 3/4"	12	4'-0 3/8"	6
4'-4 13/16"	13		
4'-8 7/8"	14	4'-8 7/16"	7
5'-0 15/16"	15		
5'-5"	16	5'-4 1/2"	8
5'-9 1/16"	17		
[illegible]1/8"	18	6'-0 9/16"	9
6'-5 3/16"	19		
6'-9 1/4"	20	6'-8 5/8"	10
7'-1 5/16"	21		
7'-5 3/8"	22	7'-4 11/16"	11
7'-9 7/16"	23		
8'-1 1/2"	24	8'-0 3/4"	12
8'-5 9/16"	25		
8'-9 5/8"	26	8'-8 13/16"	13
9'-1 11/16"	27		
9'-5 3/4"	28	9'-4 7/8"	14
9'-9 13/16"	29		
10'-1 7/8"	30	10'-0 15/16"	15
10'-5 15/16"	31		
10'-10"	32	10'-9"	16
11'-2 1/16"	33		
11'-6 1/8"	34	11'-5 1/16"	17
11'-10 3/16"	35		
12'-2 1/4"	36	12'-1 1/8"	18
12'-6 5/16"	37		
12'-10 3/8"	38	12'-9 3/16"	19
13'-2 7/16"	39		
13'-6 1/2"	40	13'-5 1/4"	20

TABLE C (NON-MODULAR)
1/2" HORIZONTAL MORTAR JOINT

HEIGHT	NO. 4" HIGH BLOCKS	HEIGHT	NO 8" HIGH BLOCKS
0'-4 1/8"	1		
0'-8 1/4"	2	0'-8 1/8"	1
1'-0 3/8"	3		
1'-4 1/2"	4	1'-4 1/4"	2
1'-8 5/8"	5		
2'-0 3/4"	6	2'-0 3/8"	3
2'-4 7/8"	7		
2'-9"	8	2'-8 1/2"	4
3'-1 1/8"	9		
3'-5 1/4"	10	3'-4 5/8"	5
3'-9 3/8"	11		
4'-1 1/2"	12	4'-0 3/4"	6
4'-5 5/8"	13		
4'-9 3/4"	14	4'-8 7/8"	7
5'-1 7/8"	15		
5'-6"	16	5'-5"	8
5'-10 1/8"	17		
6'-2 1/4"	18	6'-1 1/8"	9
6'-6 3/8"	19		
6'-10 1/2"	20	6'-9 1/4"	10
7'-2 5/8"	21		
7'-6 3/4"	22	7'-5 3/8"	11
7'-10 7/8"	23		
8'-3"	24	8'-1 1/2"	12
8'-7 1/8"	25		
8'-11 1/4"	26	8'-9 5/8"	13
9'-3 3/8"	27		
9'-7 1/2"	28	9'-5 3/4"	14
9'-11 5/8"	29		
10'-3 3/4"	30	10'-1 7/8"	15
10'-7 7/8"	31		
11'-0"	32	10'-10"	16
11'-4 1/8"	33		
11'-8 1/4"	34	11'-6 1/8"	17
12'-0 3/8"	35		
12'-4 1/2"	36	12'-2 1/4"	18
12'-8 5/8"	37		
13'-0 3/4"	38	12'-10 3/8"	19
13'-4 7/8"	39		
13'-9"	40	13'-6 1/2"	20

Notes:

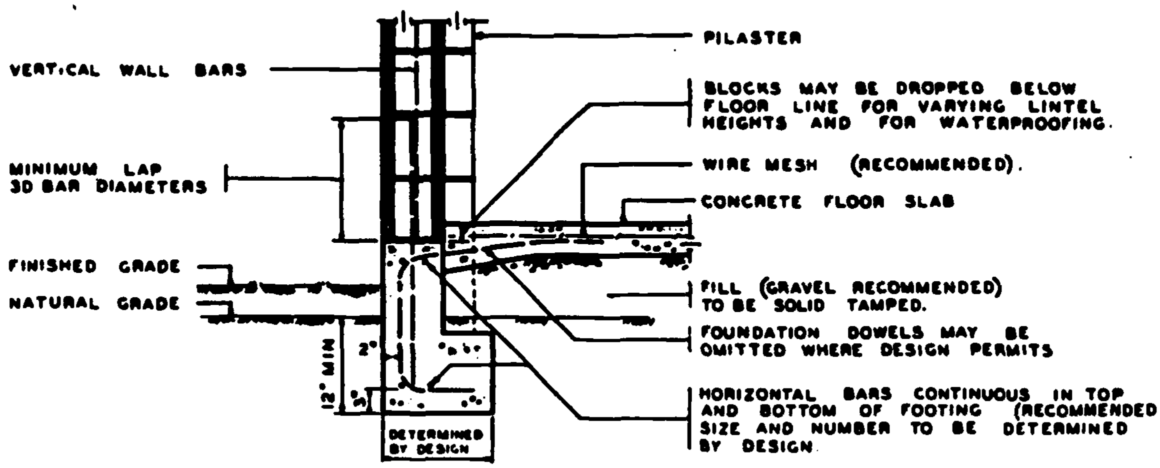
1—For exact wall length or height dimensions subtract thickness of one mortar joint.

2—For exact opening dimensions add thickness of one mortar joint to height and width.

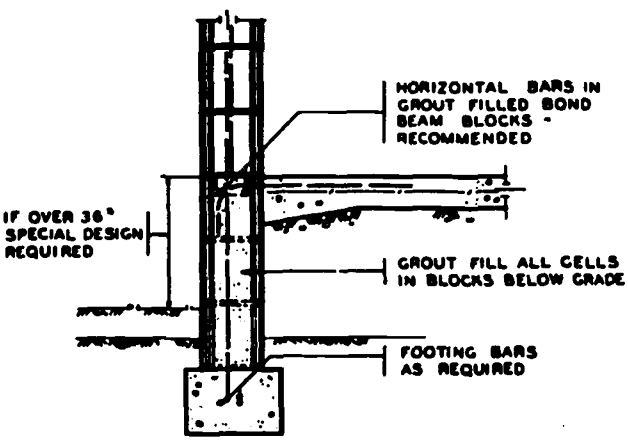
3—For design simplicity and economy of construction plan dimensions should be determined from table A (modular).

4—When using combinations of 8" high and 4" high blocks a detailed wall section should be made to establish height dimensions

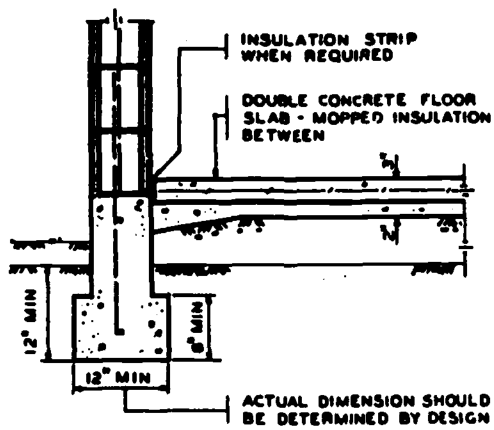
FOUNDATION DETAILS — CONCRETE FLOOR



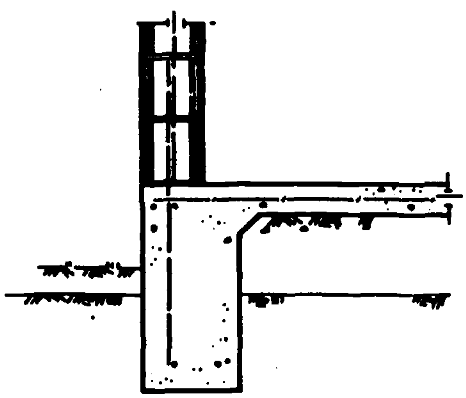
(1) Detail shown above is typical and shall apply for details 2, 3, 4 and 5 unless shown otherwise — above commercial type footing shows property line condition — center footing under wall when not on property line—



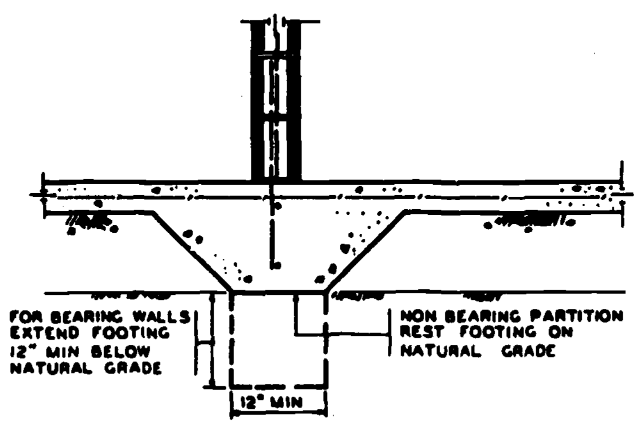
(2) Foundation wall of block recommended for continuity of appearance— above type saves constructing forms



(3) Residential type—double concrete floor slab (shown above) insures dry floor—single slab may be used



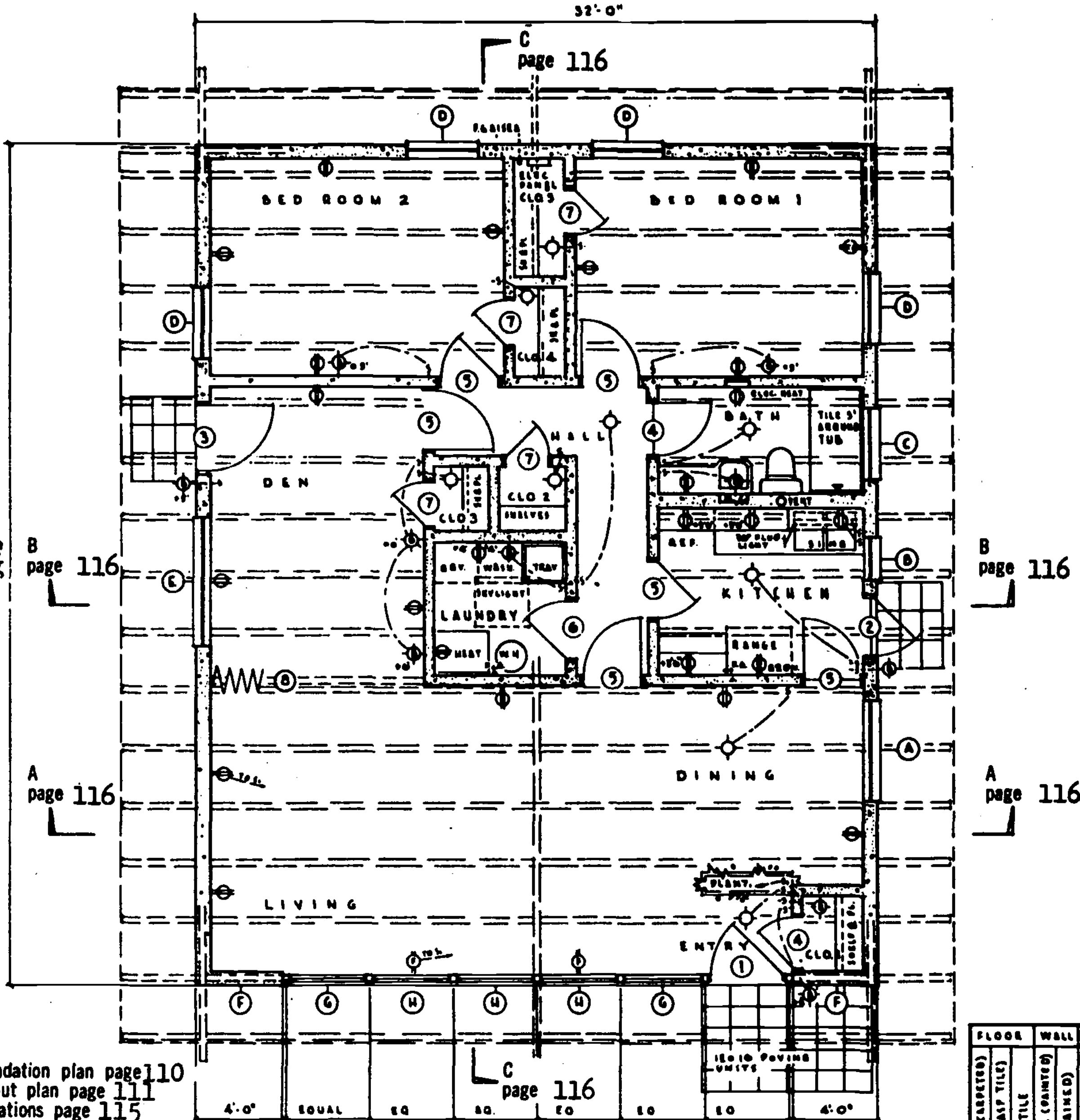
(4) Foundation and slab poured integrally—care must be used to protect floor during construction



(5) Interior wall footing

½" = 1'-0"

RESIDENCE — FLOOR PLAN



Foundation plan page 110
Layout plan page 111
Elevations page 115
Sections page 116

PLAN

SCALE 1/8" = 1'-0"

Door schedule

NO.	WIDTH	HEIGHT	THICK	REMARKS
1	-	-	1 3/4"	SPECIAL (SEE ELEV.)
2	2'-8"	6'-7 1/2"	1 3/4"	GL LOUVER (SEE ELEV)
3	3'-0"	6'-7 1/2"	1 3/4"	SEE ELEV.
4	2'-4"	6'-7 1/2"	1 3/8"	
5	2'-8"	6'-7 1/2"	1 3/8"	
6	2'-8"	6'-7 1/2"	1 3/8"	WOOD LOUVER
7	2'-0"	6'-7 1/2"	1 3/8"	
8	-	-	-	FOLDING

Window schedule

NO.	WIDTH	HEIGHT	REMARKS
A	4'-8"	4'-2 5/8"	OBS. ST. CASE
B	2'-0 1/2"	2'-2"	" " "
C	3'-4"	2'-2"	" " "
D	3'-4"	4'-2 5/8"	" " "
E	6'-0"	4'-2 7/8"	" " "
F	SPECIAL - SEE ELEVATIONS		
G	GL. LOUVER SEE ELEVATIONS		
H	SPECIAL SEE ELEVATIONS		

SEE ELEV. FOR VENTING

Electrical

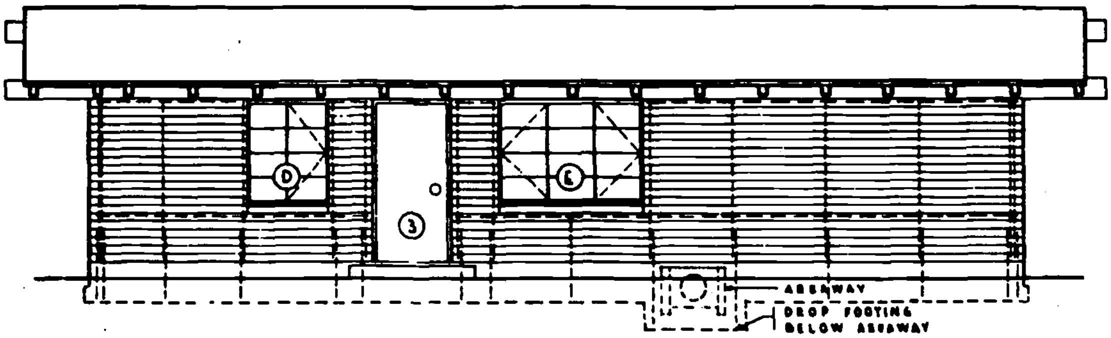
- CONVENIENCE OUTLET
- FLOOR OUTLET
- WALL BRACKET AND SWITCH (S)
- CEILING OUTLET

* 5' HEIGHT TO NEAREST BLOCK COURSE ABOVE FL. HEIGHTS NOT MARKED TO BE 12".

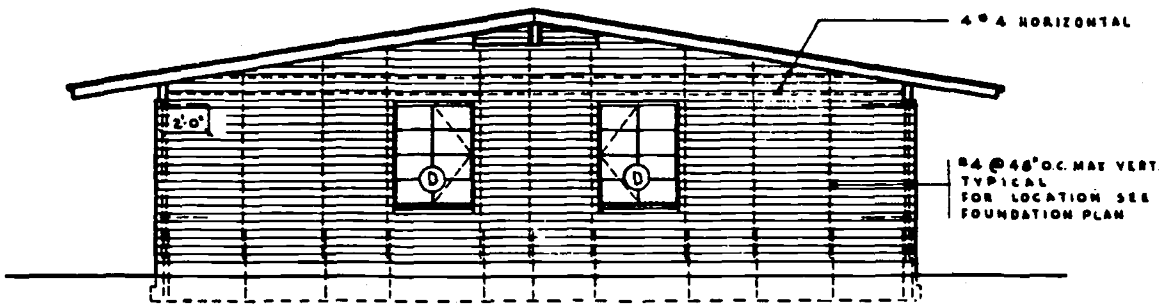
Finish schedule

	FLOOR			WALL		CEIL.	
	CONC. FL. (CARPETED)	CONC. FL. (ASP. TILE)	CERAMIC TILE	EXP. BLOCK (PAINTED)	WOOD (STAINED)	EXP. BEAM & T&G	PLASTER
LIVING, DINING, ENTRY	•			•	•	•	
DEN	•			•	•	•	
BED ROOMS 1, 2	•			•	•	•	
BATH (SEE FL. PLAN)			•	•	•	•	
KITCHEN (SEE SECTIONS)		•		•	•	•	
HALL	•			•			•
LAUNDRY		•		•			•
CLO. 1 (OPEN CEILING)	•			•			
CLO. 2, 3	•			•			•
CLO. 4, 5	•			•			•

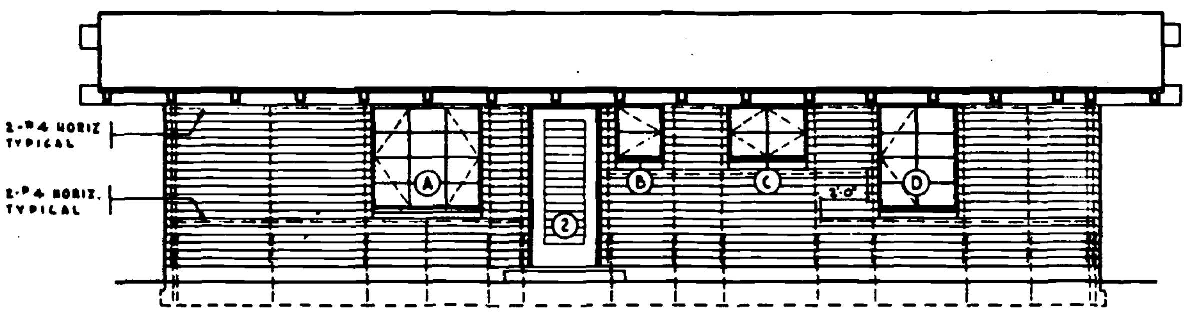
RESIDENCE — ELEVATIONS



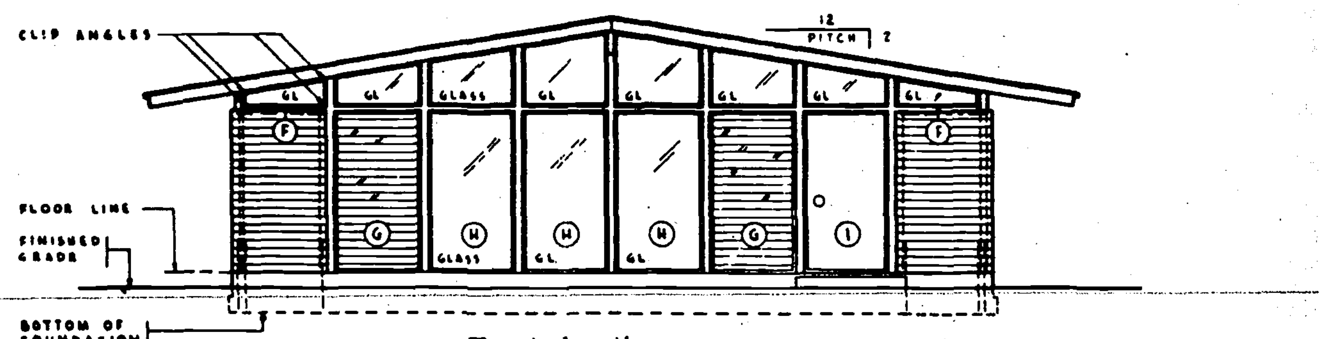
Left elevation



Rear elevation



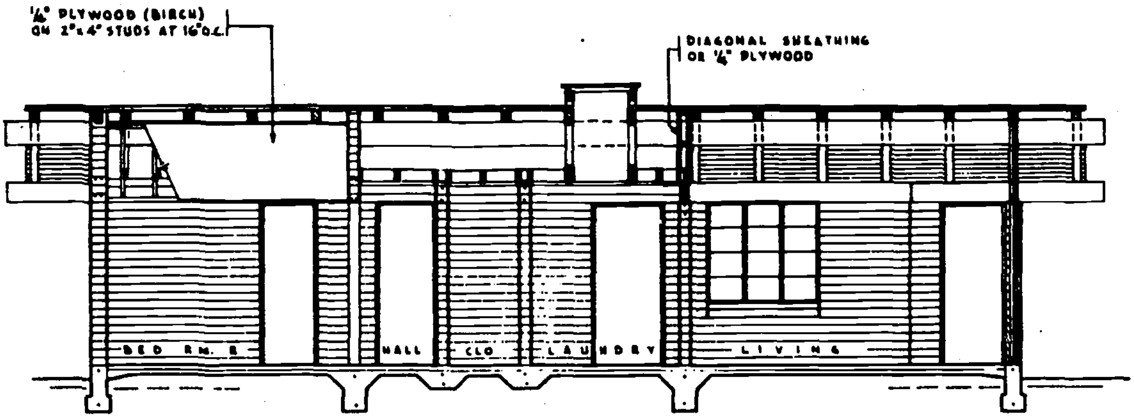
Right elevation



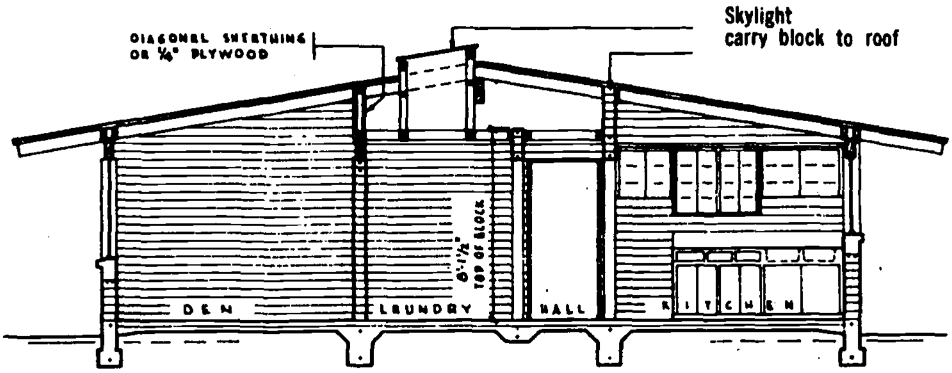
Front elevation

Foundation plan—page 110
Block layout plan—page 111
Floor plan—page 114
Sections—page 116

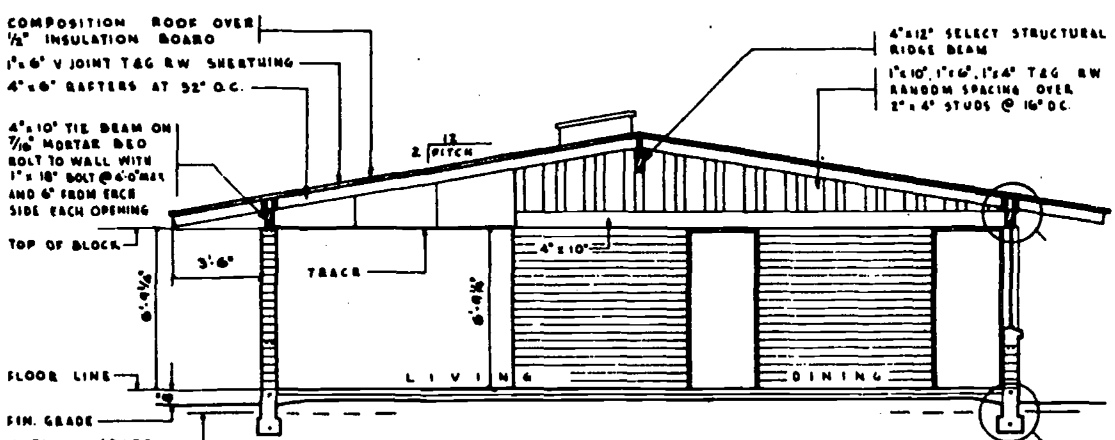
SCALE 1/8" = 1'-0"



Section C-C



Section B-B



Section A-A

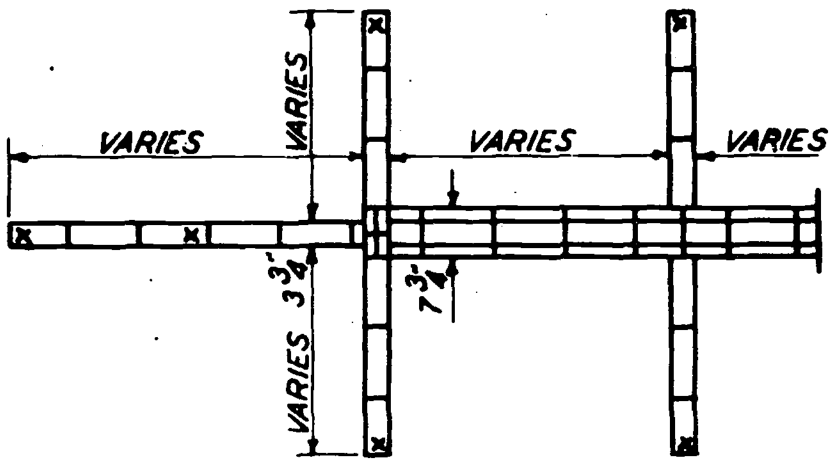
Detail No. 3
Page 113

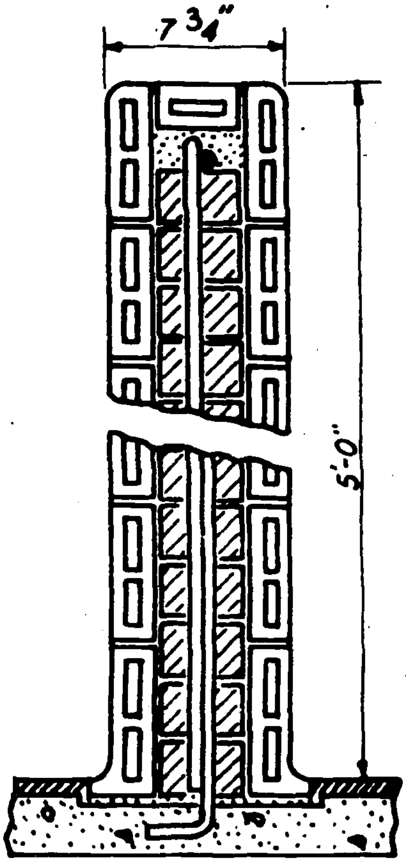
NOTES -
USE 7/16" HORIZONTAL MORTAR JOINTS.
ALL DIMENSIONS SHOWN ABOVE ARE FROM CENTER TO CENTER OF MORTAR JOINT.
FOR ACTUAL OVERALL MASONRY HEIGHTS SUBTRACT THICKNESS OF ONE MORTAR JOINT (7/16").

Foundation plan—page 110
Block layout plan—page 111
Floor plan—page 114
Elevations—page 115

SCALE 1/8" = 1'-0"

ILLUSTRATION A — REINFORCED SHOWER PARTITIONS

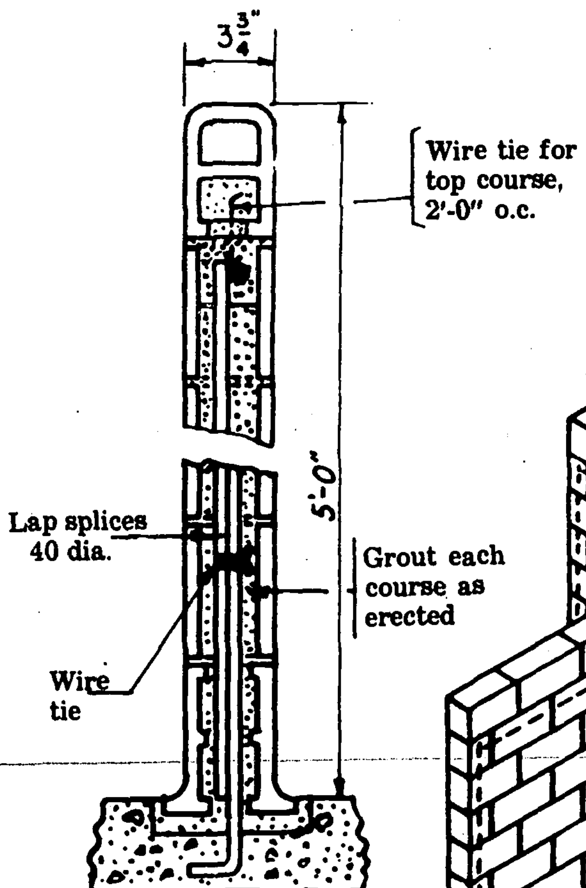




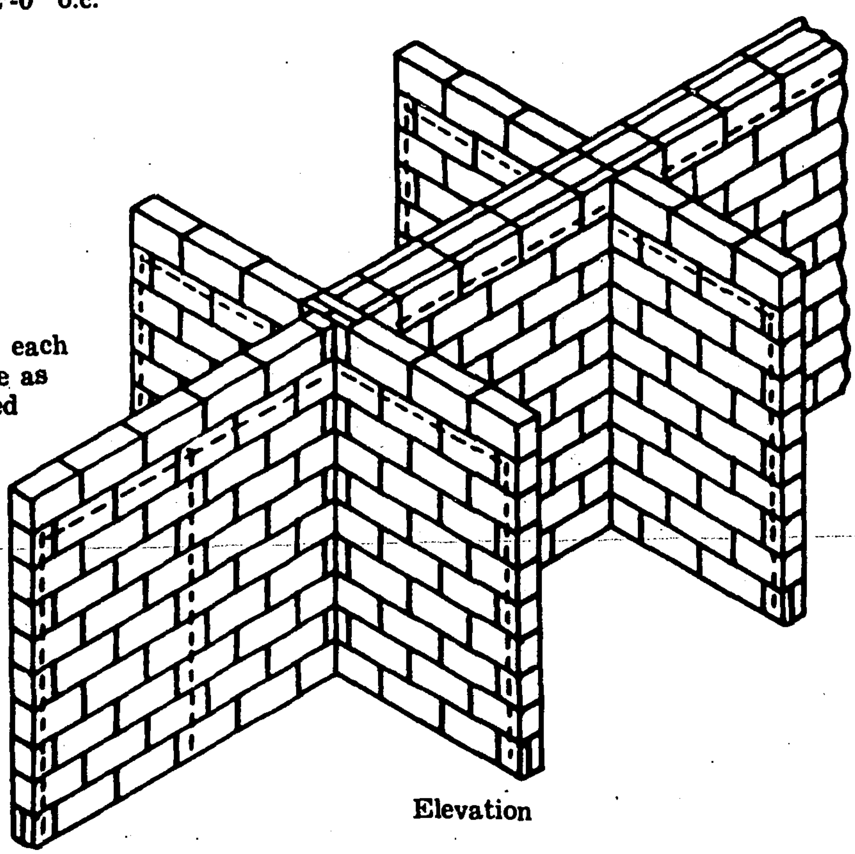
Section

- - Vertical steel placement in 4" walls 2'-6" o.c. min. to 3'-6" max. (X = steel rods)

- - Horizontal steel in gap course only, ladder type reinforcement 18" o.c. in horizontal joints.



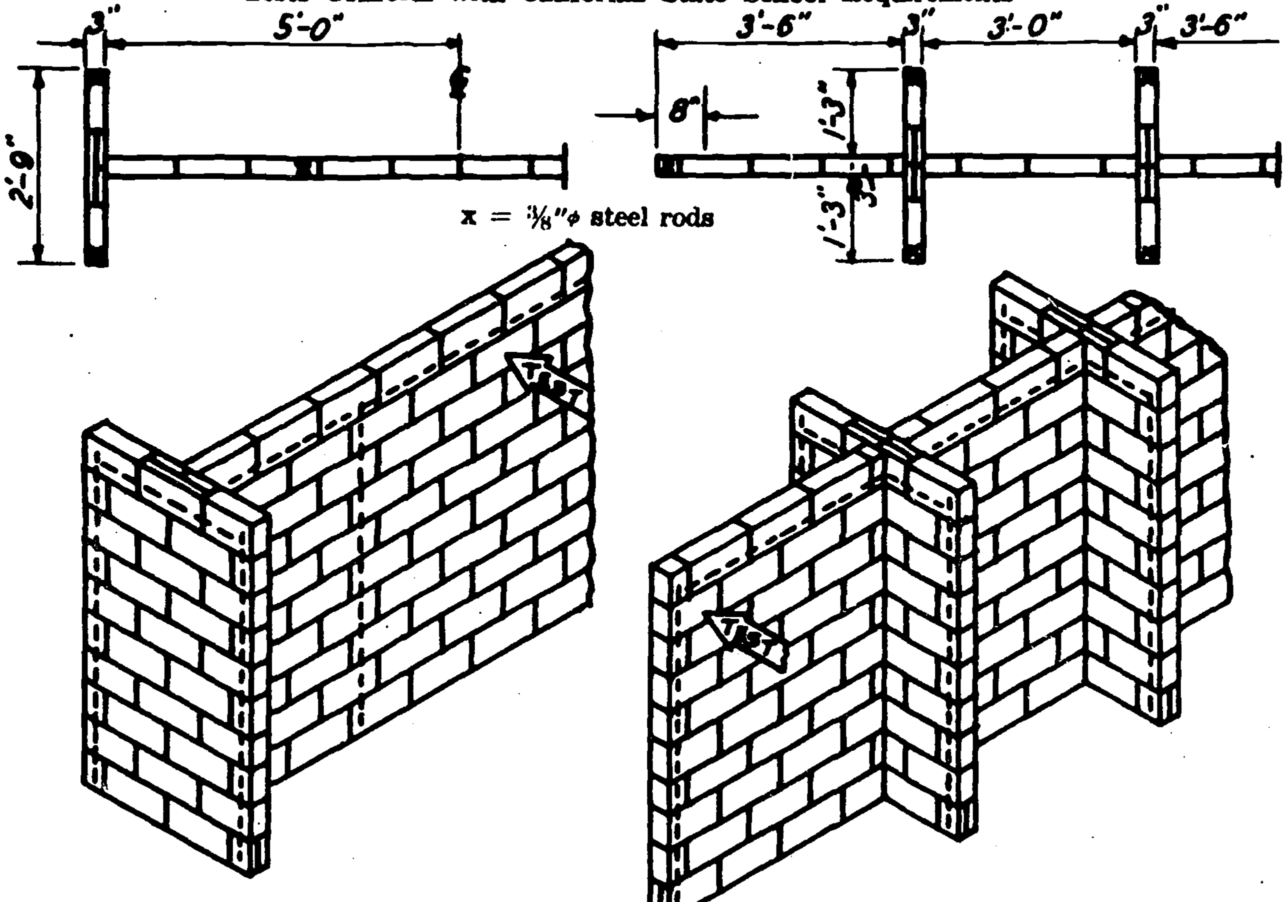
Section



Elevation

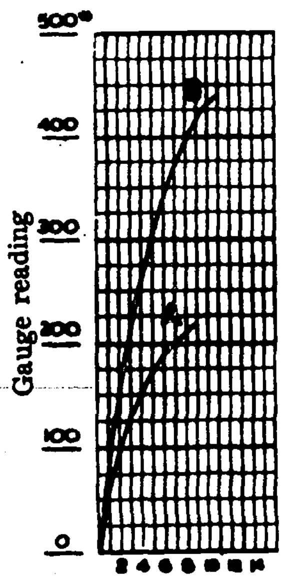
ILLUSTRATION B — SHOWER PARTITION TESTS

Tests Conform with California State School Requirements



Test —B— Test —A—

Summary of test on above walls



Deflection by 1/64"

Wall A—See above photo.

Lbs. per sq. inch pressure gauge reading	Total load pounds pressure factor 3.281	Deflection inches
204	669.32	7/64
*210	689.01	8/64
Wall B		
420	1378.02	9/64
**430	1410.86	10/64

*A—Probable ultimate load at end of wall.

**B—Probable ultimate load at center of wall.

The Hersey Testing Laboratory under observation of the State Engineer's office, made severe tests on **Kraftile Glazed Wall Units** for structural and seismic resistance.

For the purpose of testing, two typical shower walls 3" thick and 5'-0" high were constructed and internally reinforced and anchored to a concrete floor slab.

The walls were tested by applying the load in a horizontal direction with a hydraulic jack.

The total load applied was **ten times** stronger than all code requirements, equal to 100% of gravity.

Test A load was applied 4'-2" from the floor at the end of the wall.

Test B was applied 4'-2" from the floor at the center of the wall.

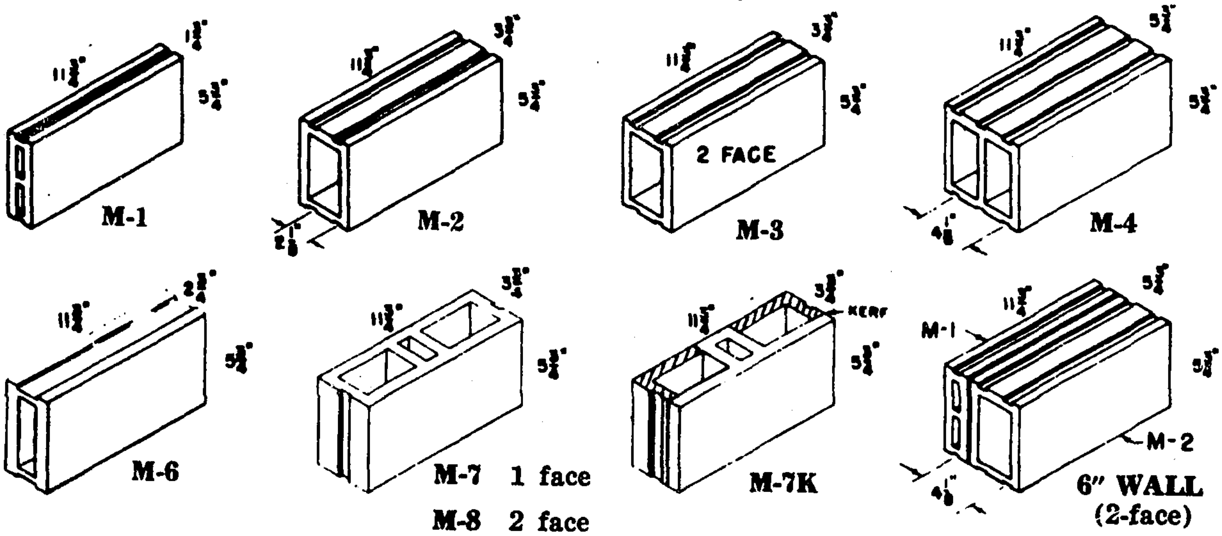
The graph reveals convincing facts—that when **Kraftile Glazed Wall Units** are erected according to specification, they will remain sound and secure.

ILLUSTRATION C — GLAZED STRUCTURAL UNITS

WESTERN STRUCTURAL TILE INSTITUTE STANDARD SHAPES
"6M"—SERIES

Glazed structural wall units are modular dimensioned to lay in the wall with a nominal dimension of 6" x 12" including ¼" joint. Net dimensions are shown.

STRETCHER GROUP

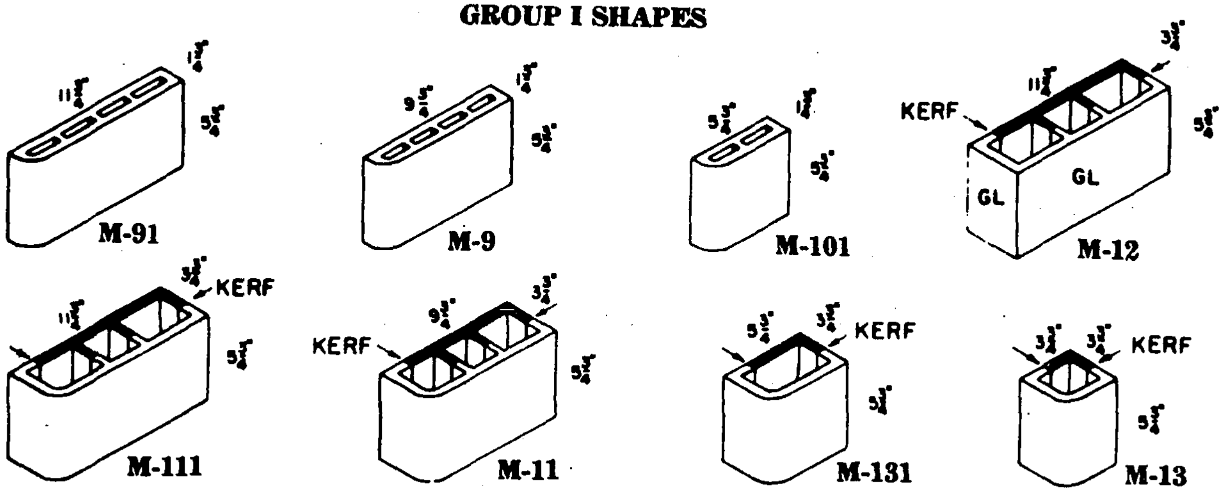


KERFING: Pieces marked "kerf" are shipped to be separated at the job, or used as full pieces, a tap with the hammer will split the pieces at the kerf line.

IF UNGLAZED face to be exposed, specify smooth-backed units.

ALL BULLNOSE CORNERS, JAMBS AND CAPS ARE 1" RADIUS; COVE BASE IS ALSO 1" RADIUS.

GROUP I SHAPES



GROUP II SHAPES
Bullnose and coves

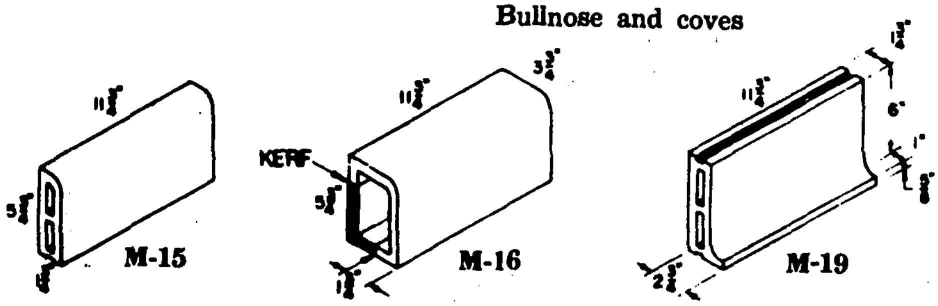
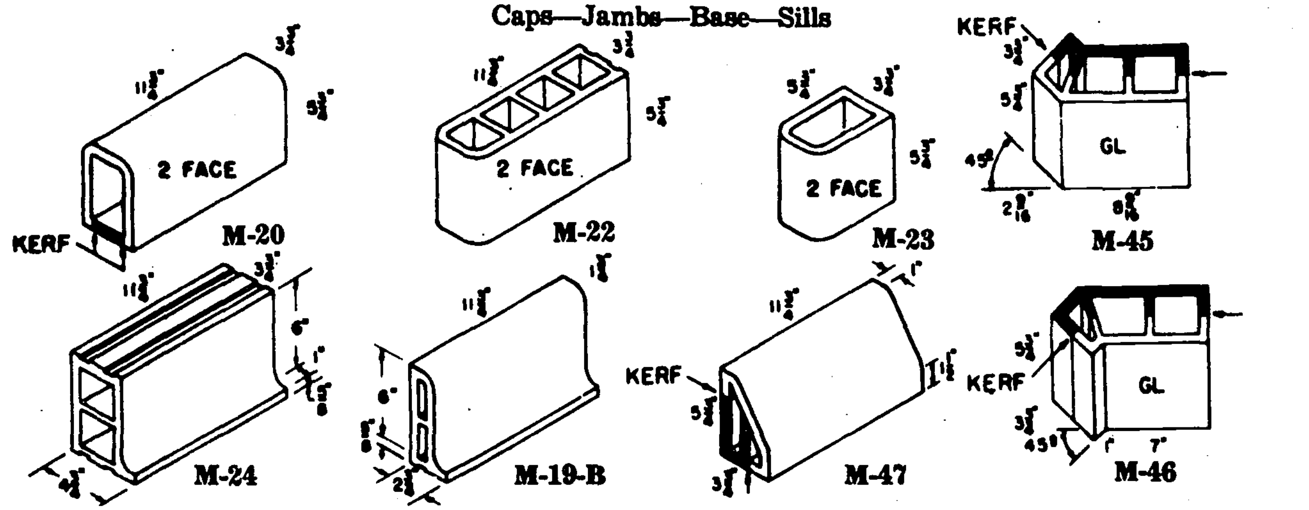


ILLUSTRATION D — GLAZED STRUCTURAL WALL UNITS

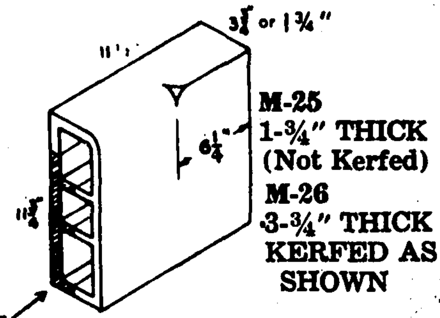
"6M" SERIES GROUP III SHAPES

Caps—Jambs—Base—Sills



GROUP IV FITTINGS

NOTE: All fittings are made 11¾" long; cut on job to shorter lengths if required. Made in right and left hand fittings SHOWN HERE IN RIGHT HAND FITTINGS ONLY.



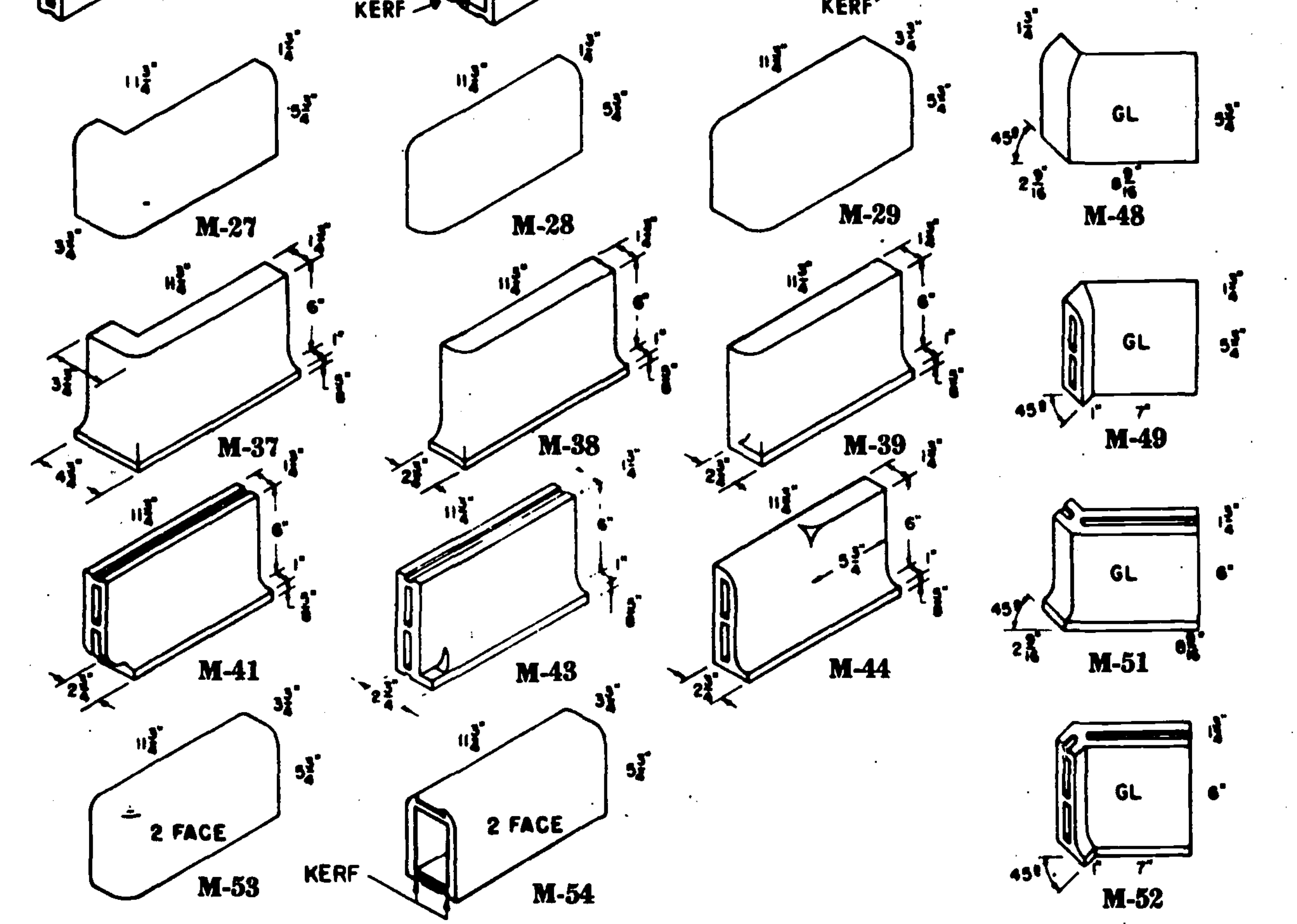
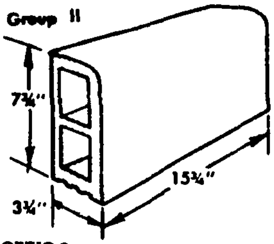


ILLUSTRATION E — GLAZED STRUCTURAL UNITS

"8W" SERIES (nominal 8" x 16" face)

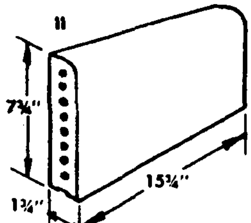
SILLS, CAPS AND MITERS



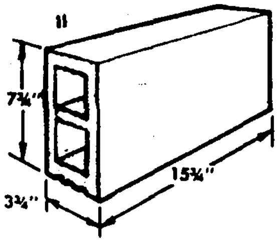
8W20

Kerfed for 8W20B

Soap



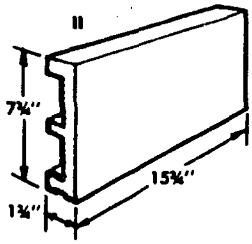
8W20A



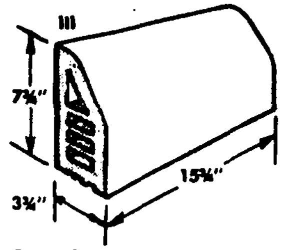
8W10

Kerfed for 8W10B

Soap



8W10A



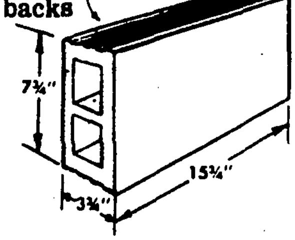
8W70

Note: Suffix B denotes Soap with 3¾" Reveal or Return.
Units designated † are Kerfed for Soap with 3¾" Reveal.

STRETCHER GROUP

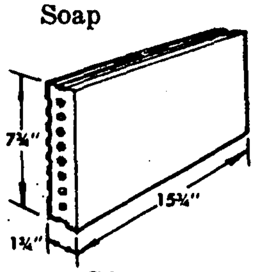
Units in this group marked * are available only subject to manufacturers' accumulation.

Scored or smooth backs



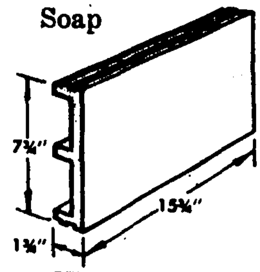
8WC 4" stretcher
8WCgr Scored back
8WCsu (unselected unglazed back) (shown)
8WCsm* (unselected glazed back)

Soap

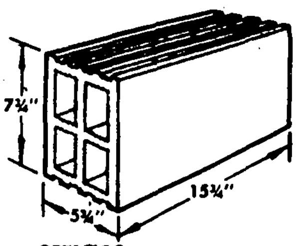


8WCA

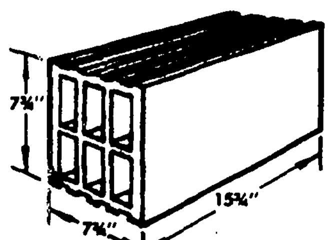
Soap



8WHA

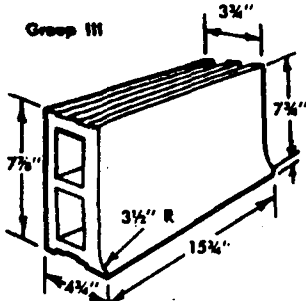


8WC60
8WC60su (shown)
8WC60gr
8WC60D (two face)
8WC60sm*

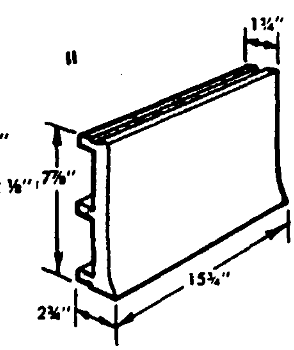


8WC80su

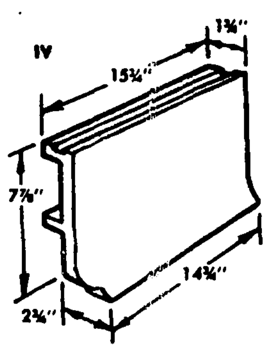
COVE BASE



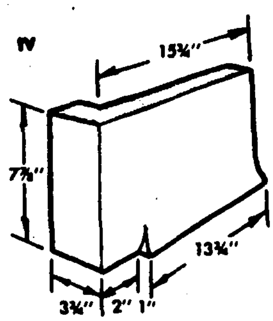
8W50N



8W50AN



8W57NR



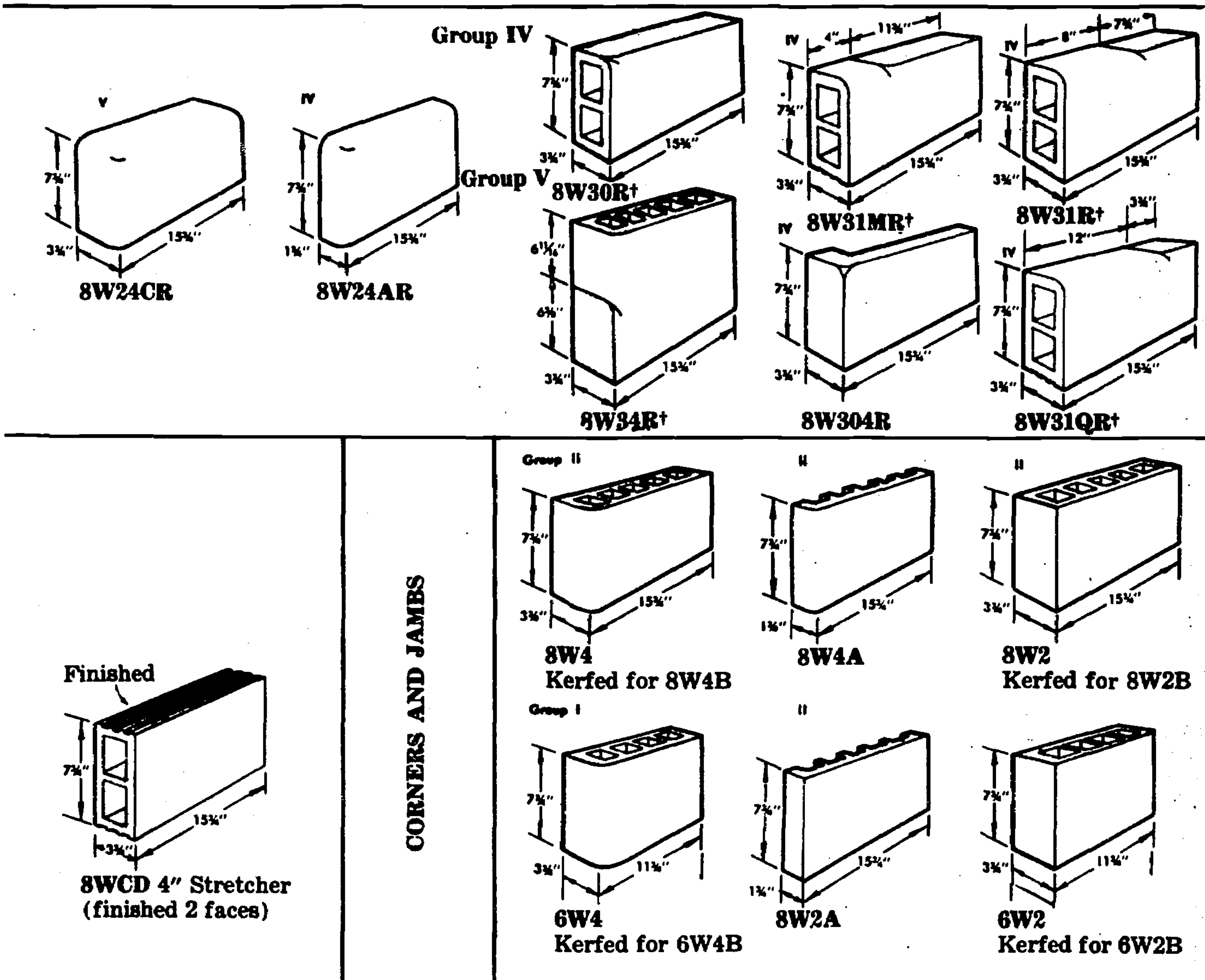
8W502NR

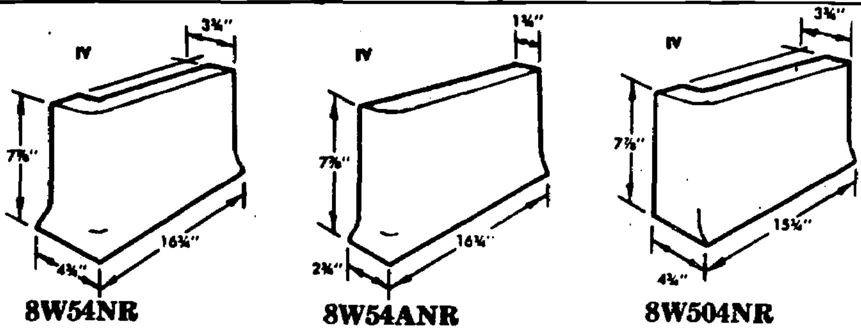
Number with suffix R denotes right hand shape; similar left hand shape takes suffix L.

Type and directions of SCORING and CORING are optional with the manufacturer. In general, the manufacturer standardizes on either the horizontal

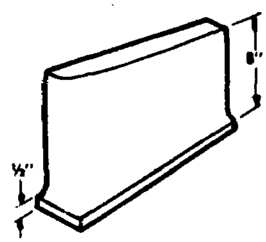
ILLUSTRATION F — GLAZED STRUCTURAL UNITS

"8W" SERIES (nominal 8″ x 16″ face)





Note:
Cove Base Units shown are non-recessed, Recessed Cove Base Units are available as an option (see Below). Recessed Base has ½″ lip below floor and 1″ cove radius.

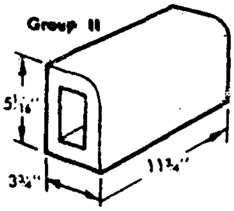


or vertical coring. Shipments may be facilitated by simply ordering stretchers, EXample: 8WC or 8WC60, thereby permitting the manufacturer to ship either the scored or smooth back stretchers or a mixture. If job conditions require that the back be of a certain type, they may be obtained by ordering the following: sm — unselected glazed back; su — unselected, unglazed back; gr — scored or groved back.

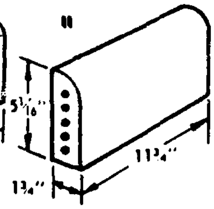
ILLUSTRATION G — GLAZED STRUCTURAL UNITS

"6T" SERIES (nominal 5⅓" x 12" face)

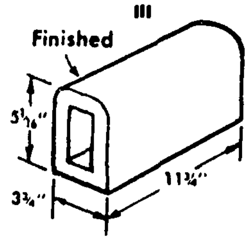
SILLS, CAPS AND MITERS



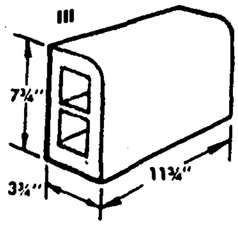
6T20
Same, square edge, 6T10
Kerfed for 6T20B



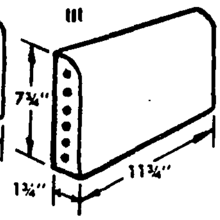
6T20A
Same, square edge, 6T10A



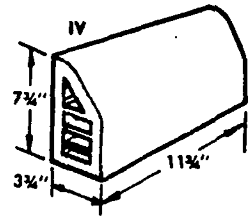
6T20D



6W20
Same, square edge, 6W10
Kerfed for 6W20B



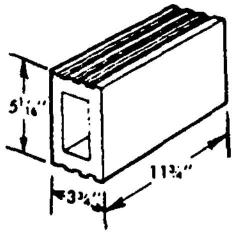
6W20A
Same, square edge, 6W10A



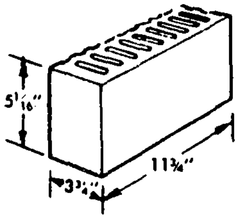
6W70

Units in this group marked * are available only subject to manufacturers' accumulation.

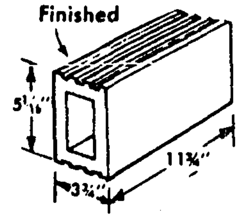
STRETCHER GROUP



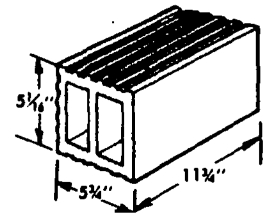
4" Stretcher
6TC
6TCgr
6TCsu (shown)
6TCsm*



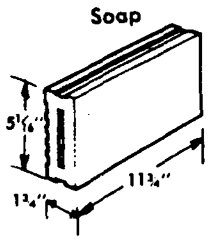
4" Stretcher
6T
6Tgr (shown)
6Tsu
6Tsm*



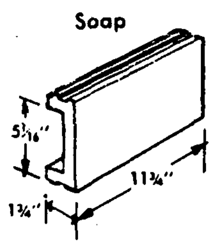
4" Stretcher
6TCD (finished 2 faces)



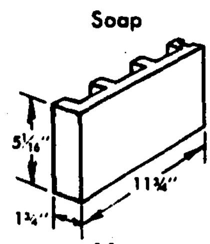
6" Stretcher
6TC60
6TC60gr (shown)
6TC60su
6TC60sm
6TC60D
(finished two faces)



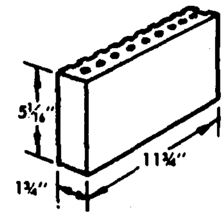
6TCA



6THA

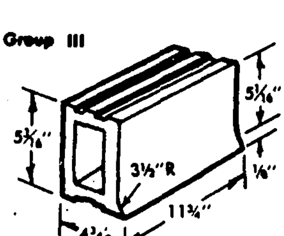


6TVA

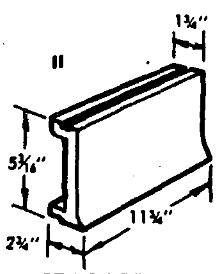


6TA

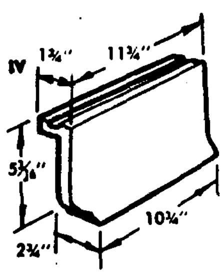
COVE BASE



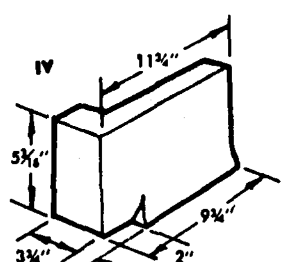
6T50N



6T50AN



6T57NR



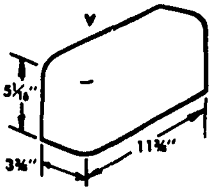
6T502NR

Number with suffix R denotes right hand shape; similar left hand shape takes suffix L.

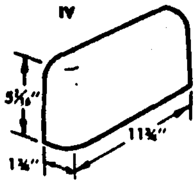
Type and directions of SCORING and CORING are optional with the manufacturer. In general, the manufacturer standardizes on either the horizontal or vertical coring. Shipments may be facilitated by simply ordering stretchers, EXAMPLE: 6T or 6TC,

ILLUSTRATION H — GLAZED STRUCTURAL UNITS

"6T" SERIES (nominal 5⅓" x 12" face)

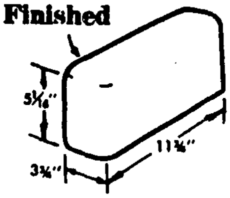


6T24CR

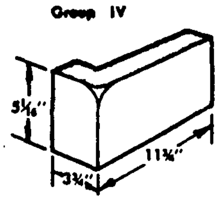


6T24AR

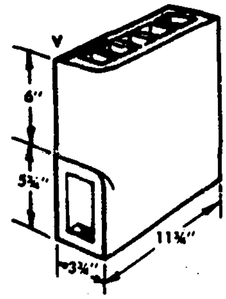
VI Finished



6T25



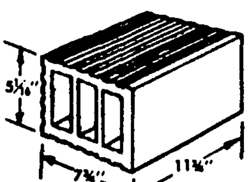
6T304R
Use with slope sills and bullnose jambs.



6N34R
Kerfed for 6N34BR
Same, Soap 3¾" return

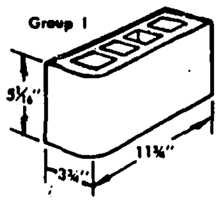
Note: Suffix B denotes Soap with 3¾" Reveal or Return.

In natural finish tile 6" & 8" bed-depth units are available in vertical core.

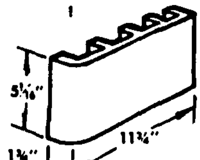


6TC80
6TC80gr (shown
6TC80su

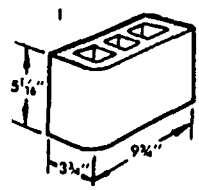
CORNERS AND JAMBS



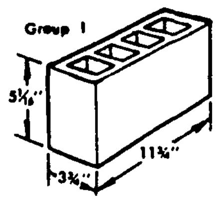
6T4
Kerfed for 6T4B



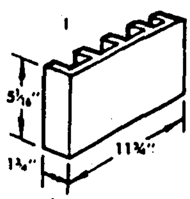
6T4A



5T4
Kerfed for 5T4B



6T2
Kerfed for 6T2B



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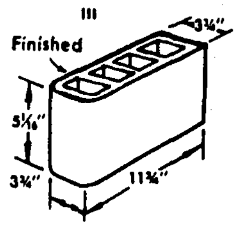

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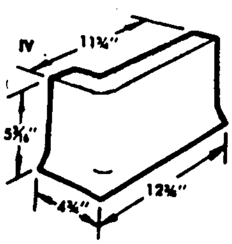

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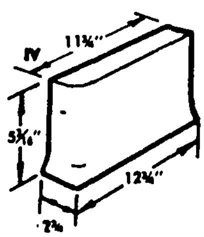

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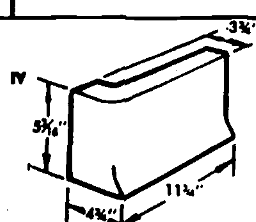


6T504NR

thereby permitting the manufacturer to ship either the scored or smooth back stretchers or a mixture. If job condition require that the back be of a certain type, they may be obtained by ordering the following: sm—unselected glazed back; su--unselected, unglazed back; gr—scored or grooved back.

Note:
Cove Base Units shown are nonrecessed. Recessed Cove Base Units are available as an option (see below). Recessed Base has ½" lip below floor and 1" Cove radius.

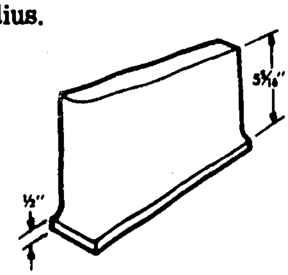
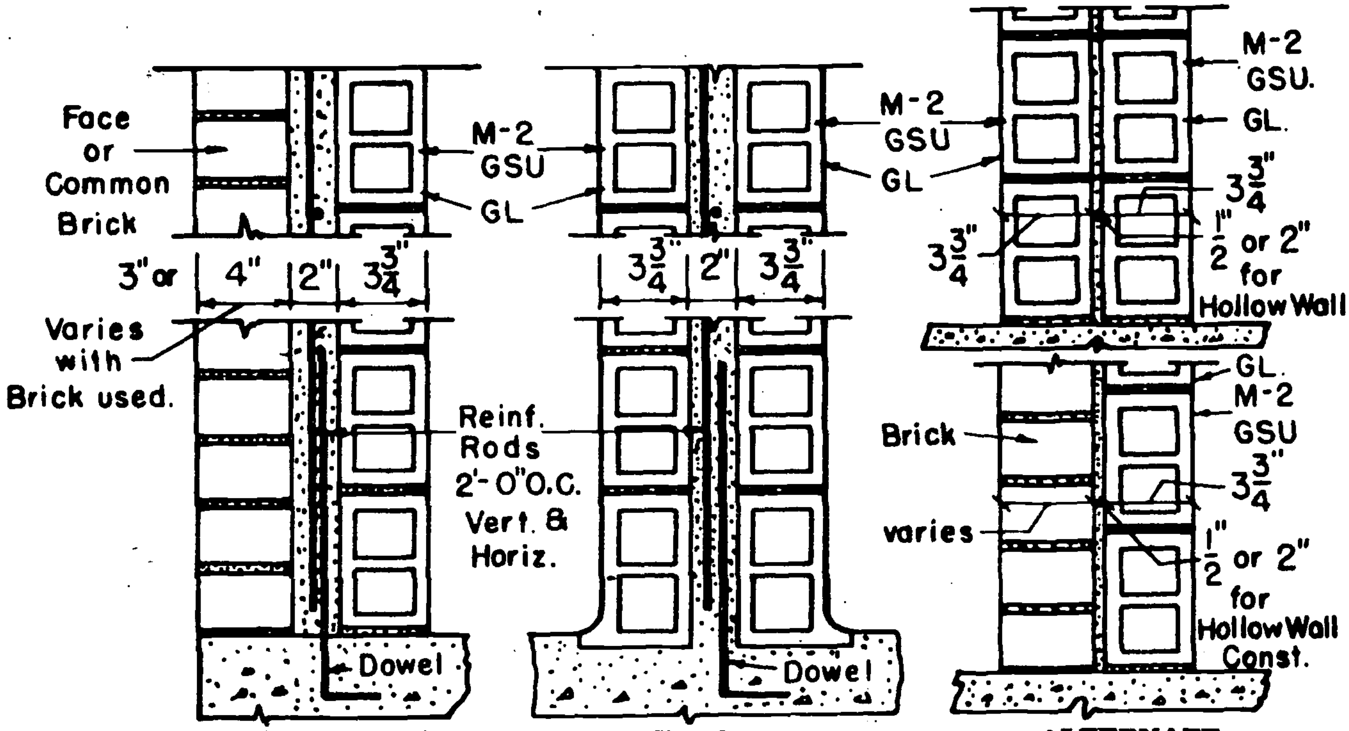


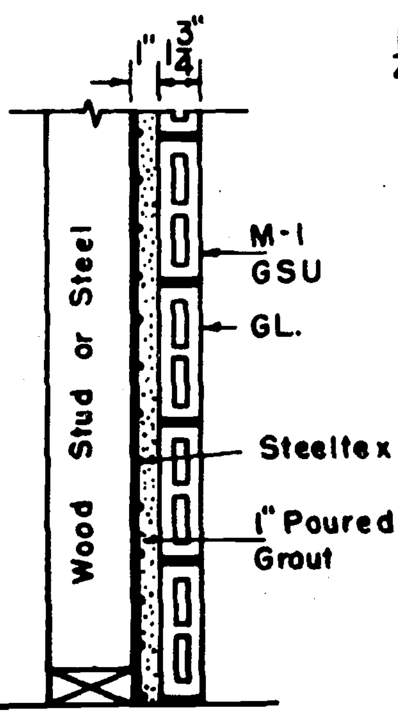
ILLUSTRATION I — GLAZED STRUCTURAL WALL DETAILS



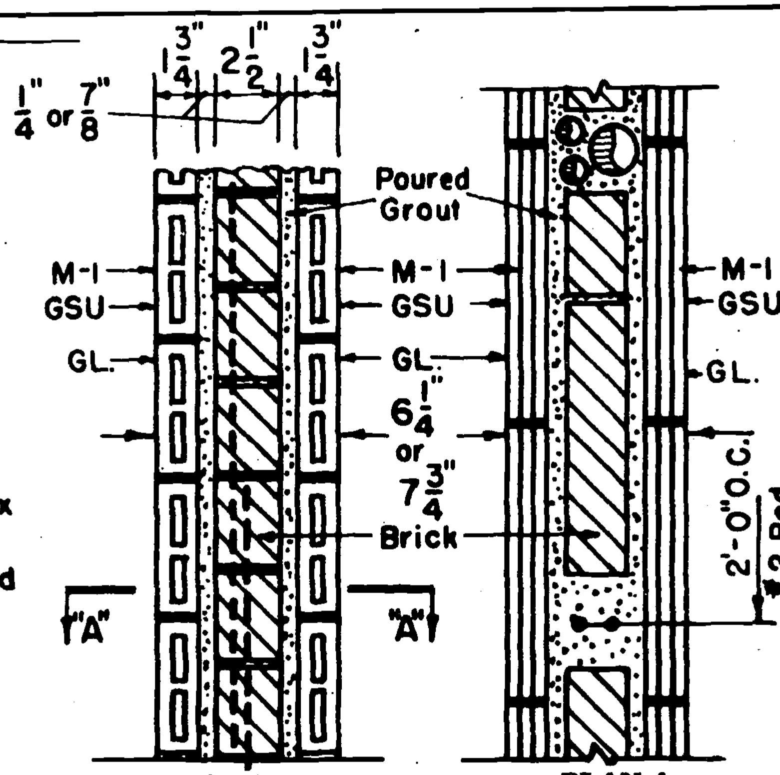
BRICK & GSU | **GSU INTERIOR**

LOAD BEARING-REINFORCED-FOR CONSTRUCTION IN AREAS WHERE REQUIRED.

ALTERNATE LOAD BEARING WHERE REINFORCING NOT REQUIRED.



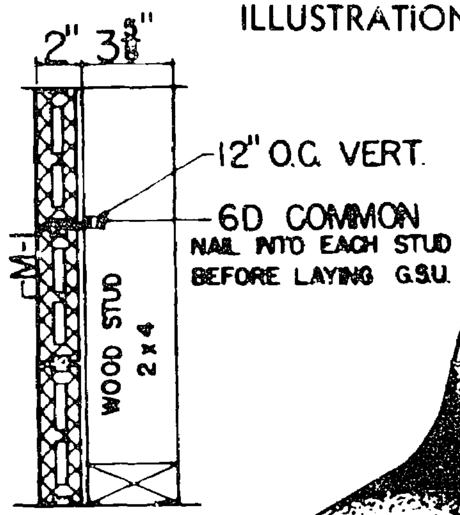
WOOD STUD & WIRE MESH REINFORCED VENEER CONSTRUCTION

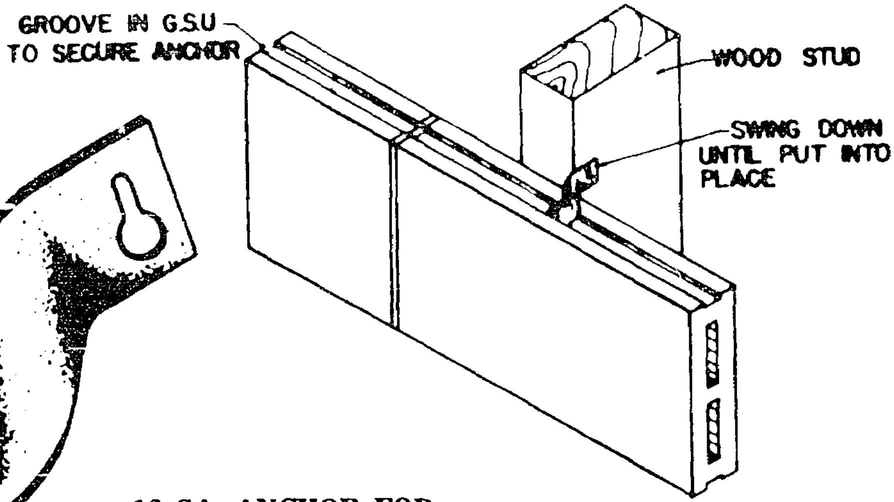


SECTION | **PLAN-A**

DOUBLE FACE REINFORCED WALL WITH PLUMBING

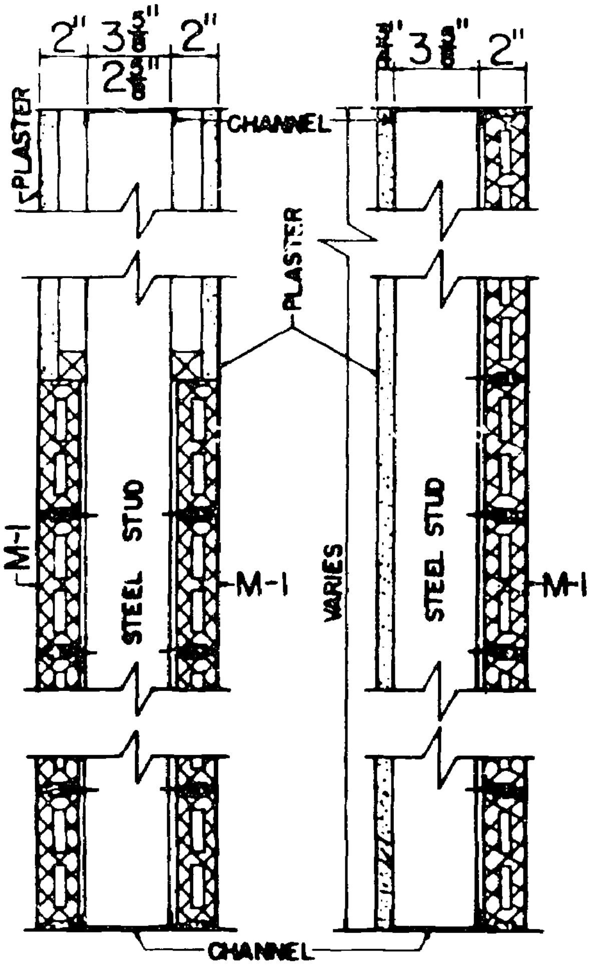
ILLUSTRATION J — GLAZED WALLS AND CLIP DETAILS



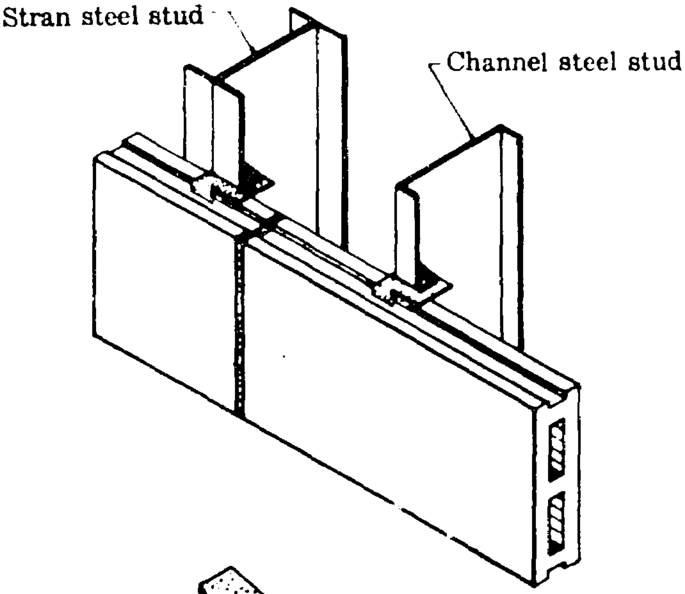


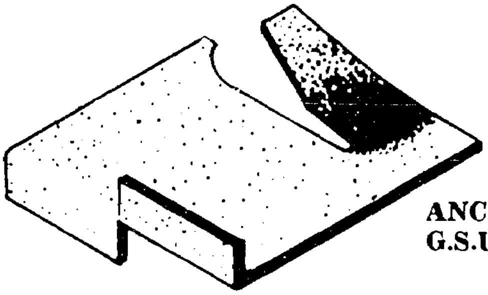
16 GA. ANCHOR FOR G.S.U. TO WOOD STUDS

Wall section
scale 1½" = 1'-0"



Wall section
scale 1½" = 1'-0"





ANCHOR CLIP FOR G.S.U. TO STEEL STUDS

ILLUSTRATION K — WALL-BASE AND WAINSCOT DETAILS

Abbreviations:

G.S.U.—Glazed Structural Units
C.G.S.U.—Ceramic Glazed Structural Units

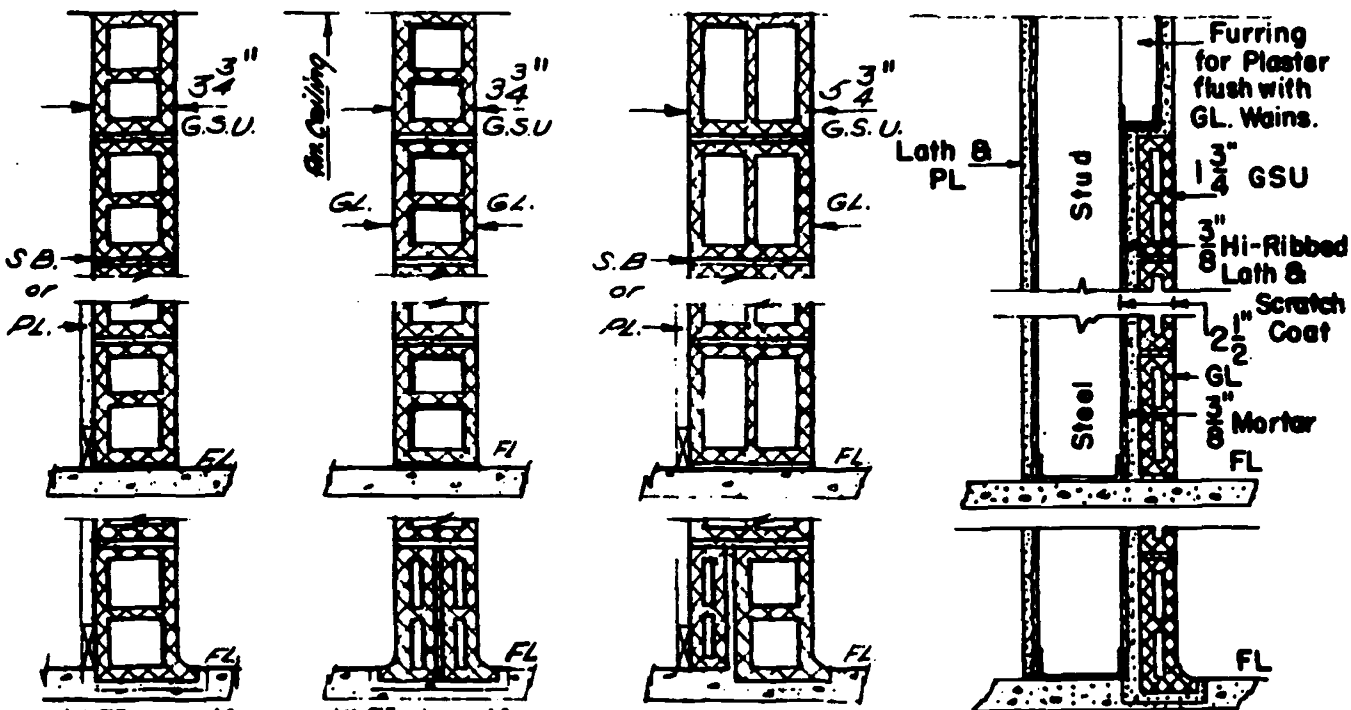
CL.G.S.U.—Clear Glazed Struc. Units
U.G.—Unglazed
S.B.—Smooth Backs
B.N.—Bullnose
Q.T.—Quarry Tile
G.L.—Glazed Surface

Standard Design:
Bullnose Corners—1" radius
Cove Base—1" radius

Modular Dimensioned:
"Nominal" Dimensions = height or length of tile including joint.
"Net" Dimension = size, not including joint. See "M" Series units.

Dimension Selection:
Dimensions shown for pipe furring and spaces, sill heights, reveals, etc. are obtainable without cutting. Other dimensions are possible by cutting tile with a saw on the job.

Course Heights:
Note—With 6" x 12" nominal units, the course height dimensions will be multiples of 6" courses. Heads of doors, windows and openings should be worked to even courses and sills to even courses plus sill thickness whenever possible.



4" GL. one side

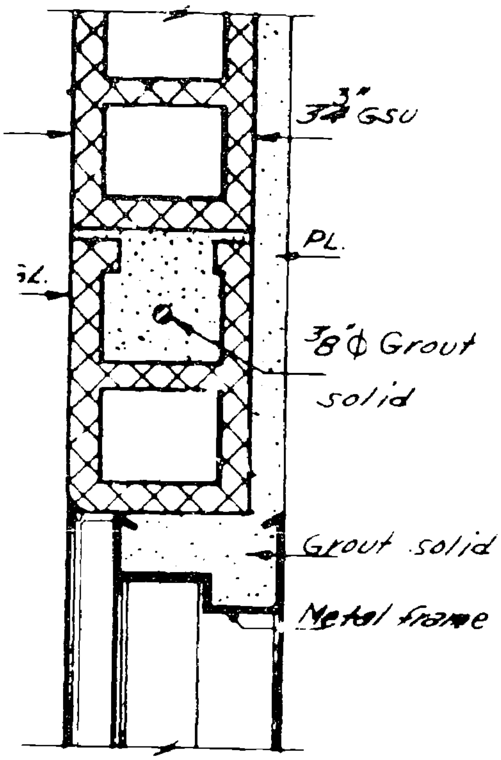
4" GL. two sides

6" GL. one side

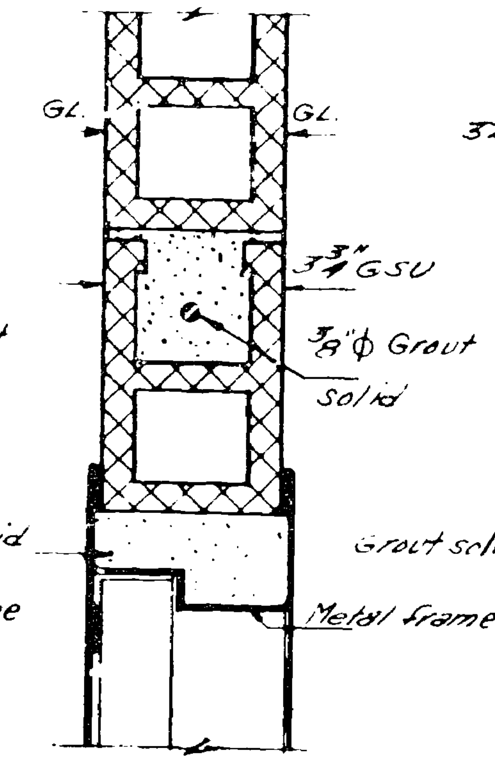
GSU on steel studs

NOTE: Alternate base details

ILLUSTRATION L — DOOR HEAD AND JAMB DETAILS



Head



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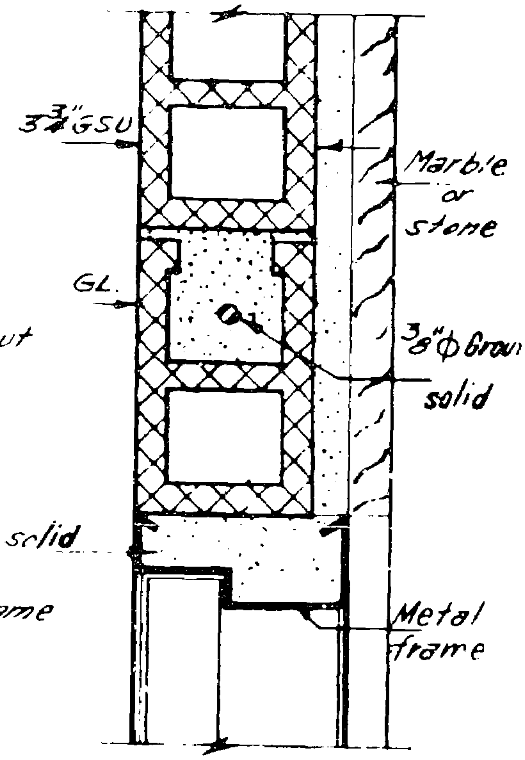

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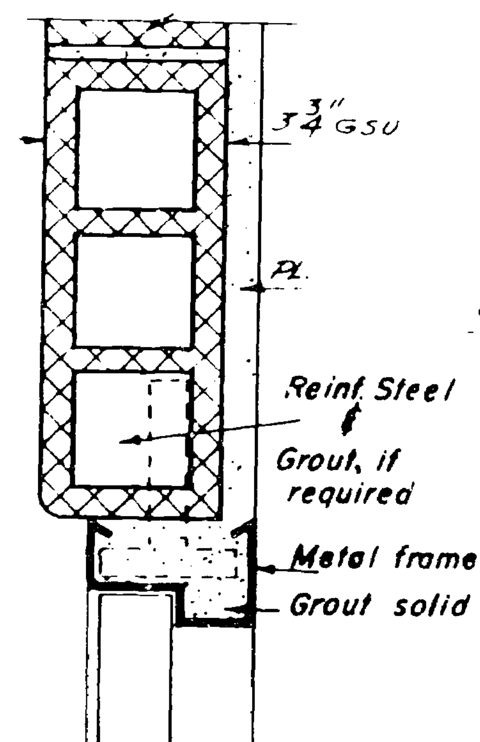
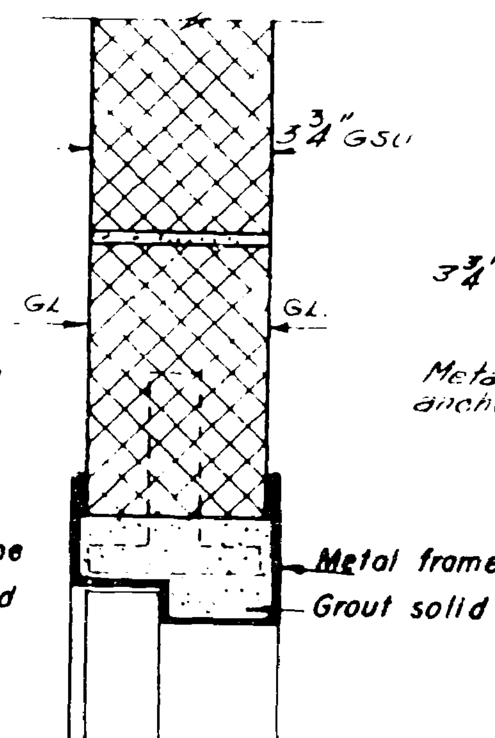
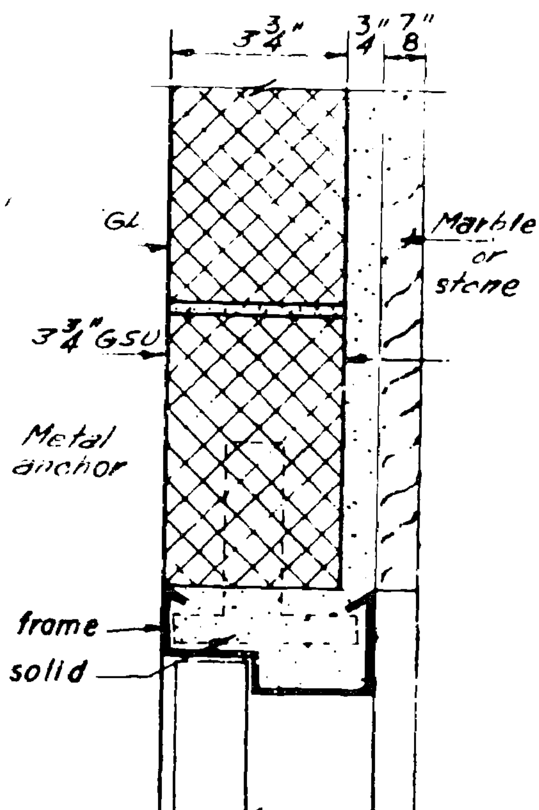


Jamb

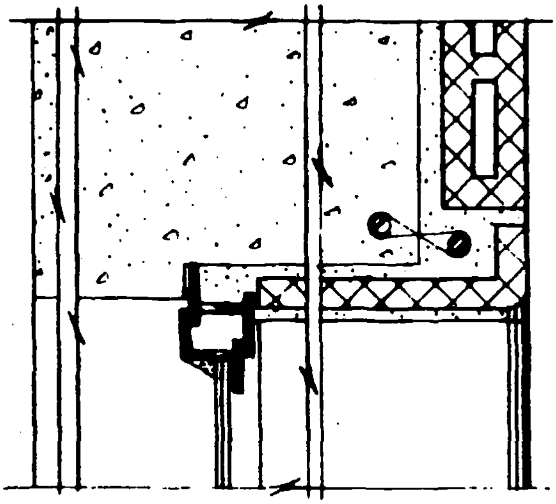


Jamb



Jamb

ILLUSTRATION M — WINDOW-HEAD-JAMB AND SILL DETAILS



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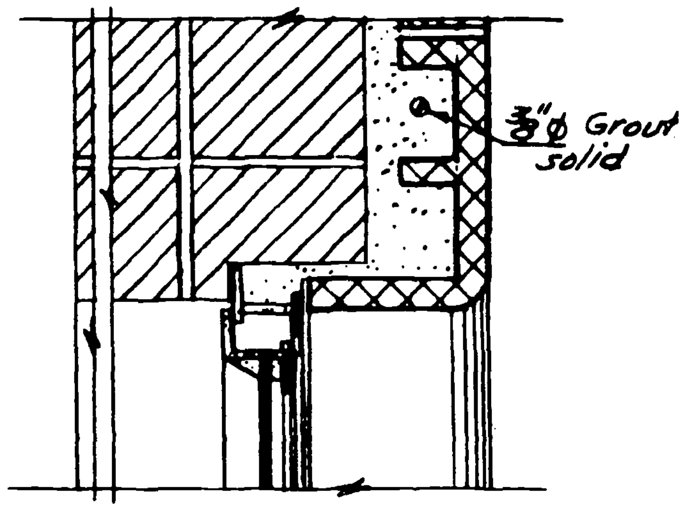

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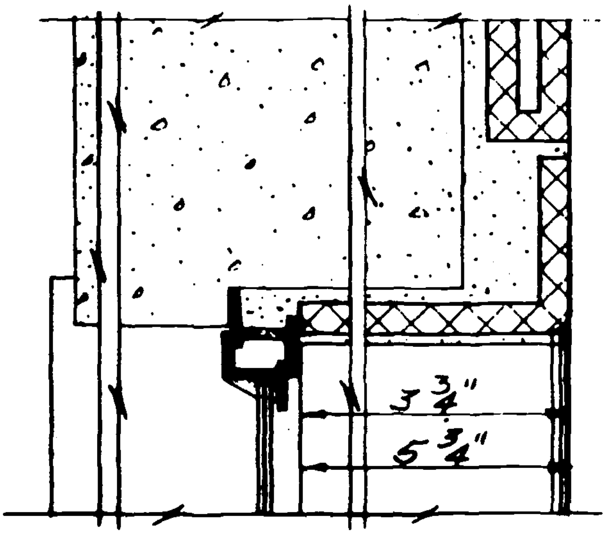

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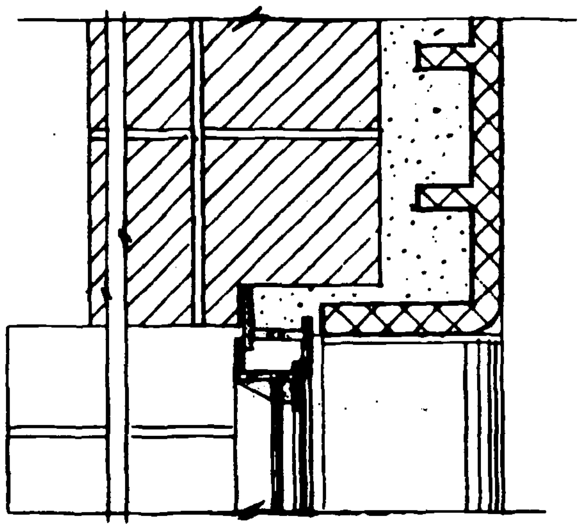

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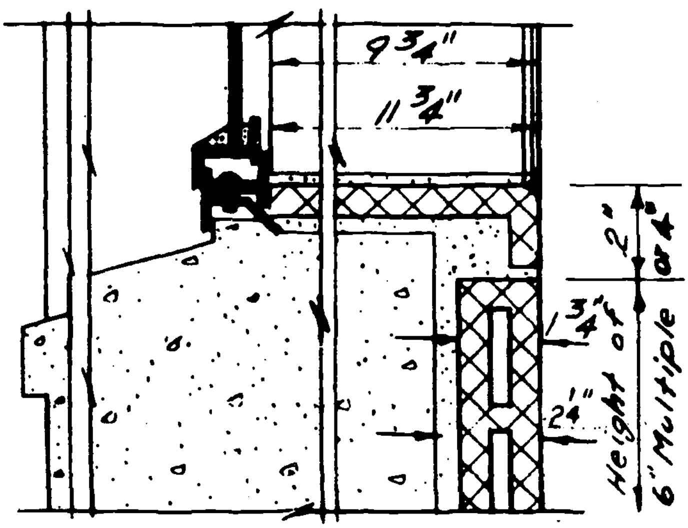
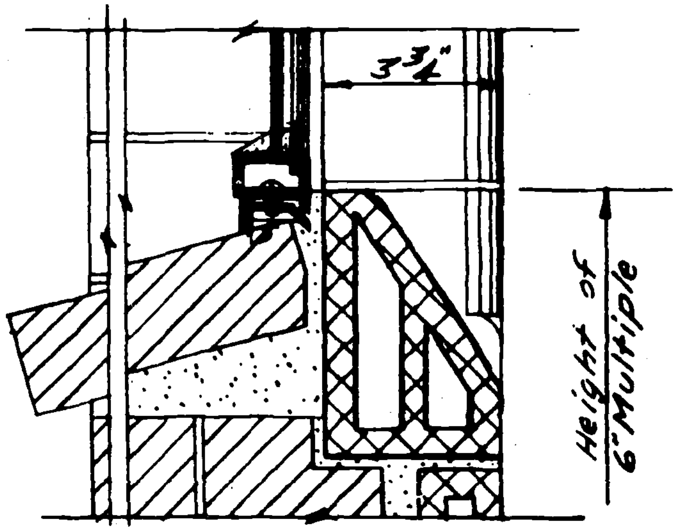


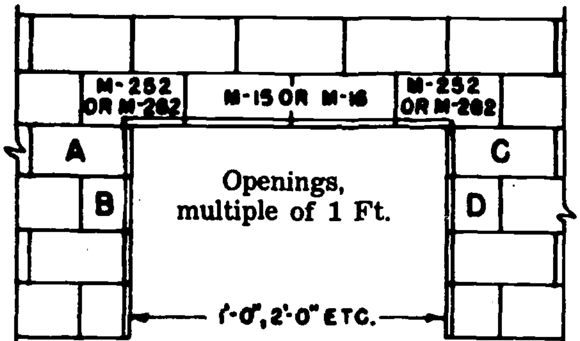
1¾" Furring tile



Sill
1¾" Furring tile

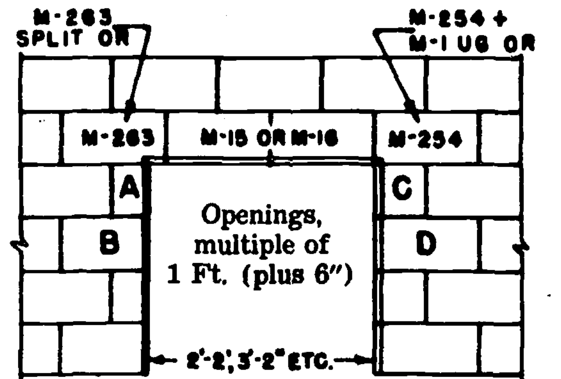
ILLUSTRATION N — STANDARD OPENING WIDTHS

DOOR AND WINDOW OPENING WIDTHS
OBTAINABLE WITH STANDARD BULLNOSE UNITS



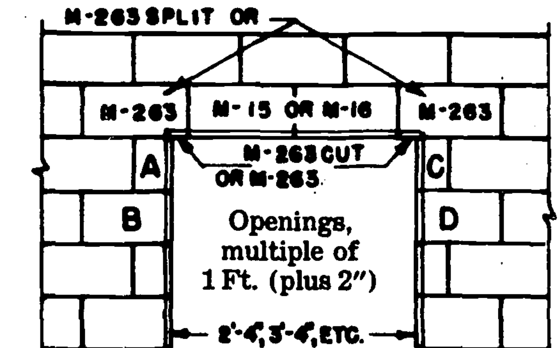
JAMBS

WALL THICKNESS	A	B	C	D
1¾"	M-91	M-101	M-91	M-101
3¾"	M-111	M-131	M-111	M-131



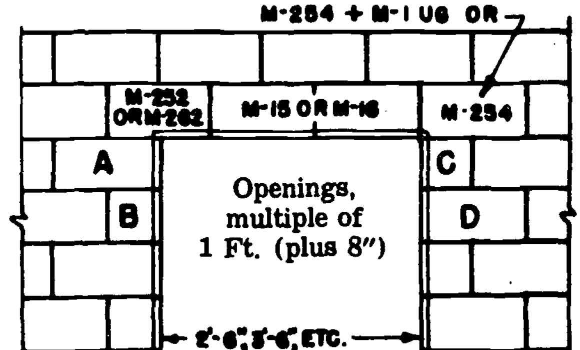
JAMBS

WALL THICKNESS	A	B	C	D
1¾"	M-101 CUT	M-9	M-101	M-91
3¾"	M-13	M-11	M-131	M-111



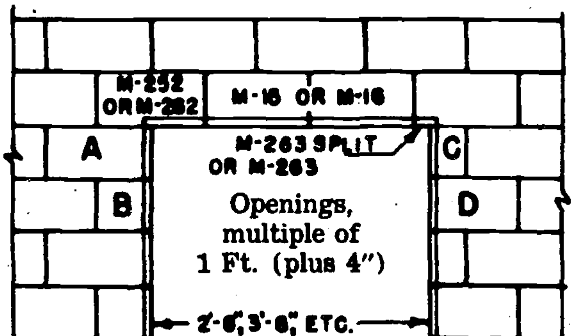
JAMBS

WALL THICKNESS	A	B	C	D
1¾"	M-13 CUT	M-9	M-13 CUT	M-9
3¾"	M-13	M-11	M-13	M-11



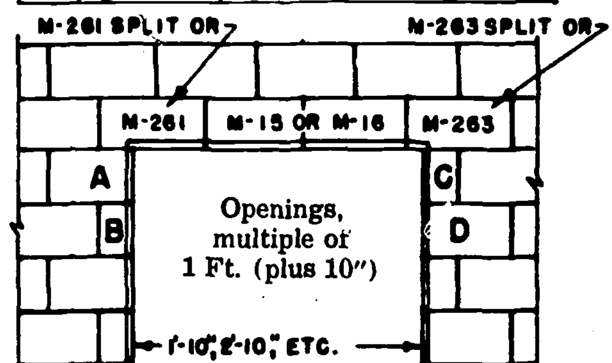
JAMBS

WALL THICKNESS	A	B	C	D
1¾"	M-91	M-101	M-101	M-91
3¾"	M-111	M-131	M-131	M-111



JAMBS

WALL THICKNESS	A	B	C	D
1¾"	M-91	M-101	M-13CUT	M-9
3¾"	M-111	M-131	M-13	M-11

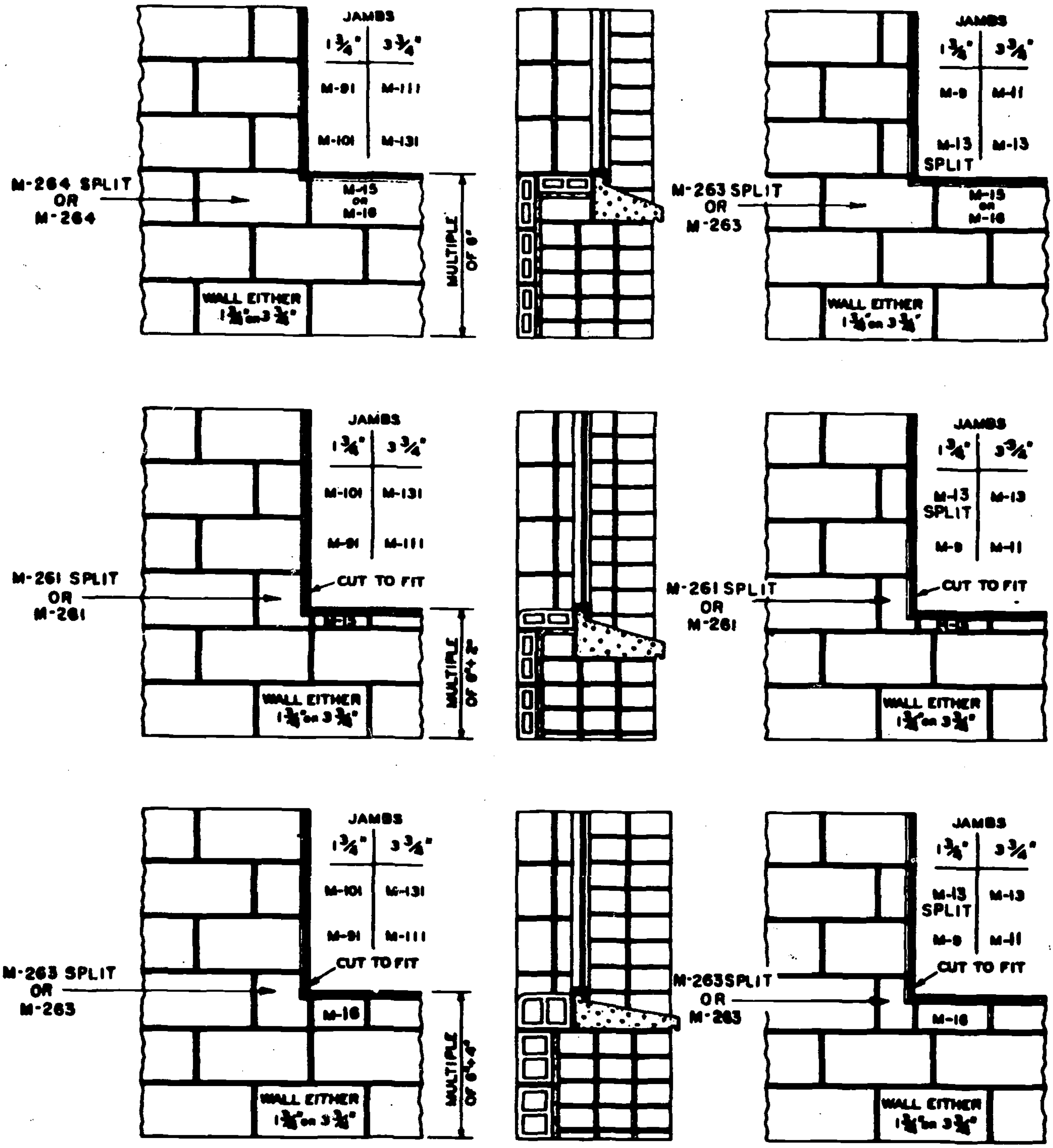


JAMBS

WALL THICKNESS	A	B	C	D
1¾"	M-9	M-13CUT	M-13CUT	M-9
3¾"	M-11	M-13	M-13	M-11

ILLUSTRATION O — STANDARD SILL HEIGHTS AND DETAILS

WINDOW SILL HEIGHTS AND DETAILS WITH STANDARD MODULAR UNITS



CHAPTER VII

CONCRETE AND REINFORCING STEEL

Quality concrete is obtained by carefully proportioning a mixture of cement, sand and gravel or other aggregates together with water. The bulk of the mix consists of fine and coarse aggregates. Cement and water interact chemically and bind the aggregates into a solid mass. The concrete mixture must be workable enough to surround the reinforcing steel when being placed and form itself into a voidless shape until hardened. The strength properties of concrete can be varied by proper adjusting of the aggregates, cement and water and also by the introduction of High-Early strength cements, and special aggregates such as lightweight or heavy aggregates.

The strength of concrete depends to a very great extent upon the proportions of the mix and the thoroughness with which the constituents are intermixed and on the conditions of humidity and temperature maintained during the placing and curing until it is fully hardened. A high degree of control and inspection is required from the proportioning of the mix through the placing and curing period.

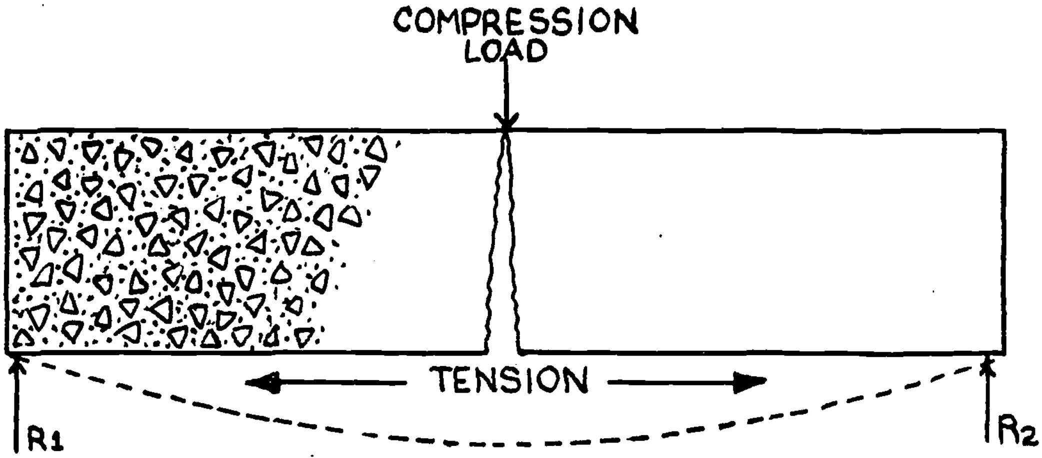
Concrete has been used for thousands of years because of its versatility:

1. It can be deposited in its plastic state to fill forms of almost any shape.

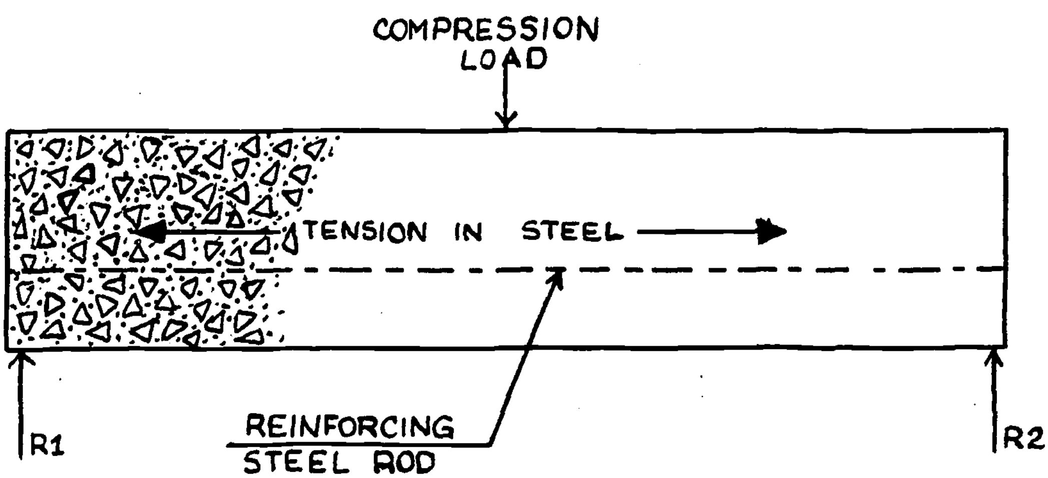
2. It has a high fire and weather resistance.

3. With the exception of cement, the aggregates, sand and water are usually available locally at low cost.

The compressive strength of concrete is as high as natural stone which makes it most suitable for building members subject primarily to compression such as columns, walls and arches. However, concrete has very little value in tension which restricts its use for structural members subject to tension such as beams and other flexural members.



To overcome the limitation of the low value of tension, steel with its high tensile strength is added to reinforce the concrete where its low tensile strength would limit the load carrying capacity of the member. Usually round steel reinforcing rods with surface deformations to provide a bonding surface for the concrete are used. The steel is placed in the forms prior to placing the concrete. When the steel is completely surrounded by the hardened concrete mass, it forms an integral part of the member and accepts the tension loading.



The use of reinforcing steel makes concrete an excellent construction material with good compressive and tension resistant qualities that can be formed to any practical shape or form. It is the combination of steel and concrete which allows almost unlimited uses and possibilities in construction of buildings, bridges, dams, storage tanks and many other structures and facilities.

It is possible to produce concrete two and three times as strong in compression as ordinary concrete. This is called prestressed concrete. By utilizing high strength steel, mostly in the shape of wires or strands and sometimes in bars, it is embedded in the concrete under high tension and held in equilibrium by compression stresses in the surrounding concrete after hardening. This precompression of the concrete in a flexural member will permit much larger loading before the member will crack on the tension side. This also reduces deflections and tensile cracks.

Figure 7-1 shows some of the more common reinforced concrete forms:

(a) Slab, beam and girder floor

(b) Ribbed floor

(c) Flat slab floor

(d) Rigid-frame structure

(e) Cylindrical shell roof

(f) Folded-plate roof

(g) Multiple-arch bridge

(h) Shell roof

(i) Storage tank

(j) Rigid-frame bridge

(k) Counterfort retaining wall

(l) Hyperbolic-paraboloid

(m) Point-supported dome roof

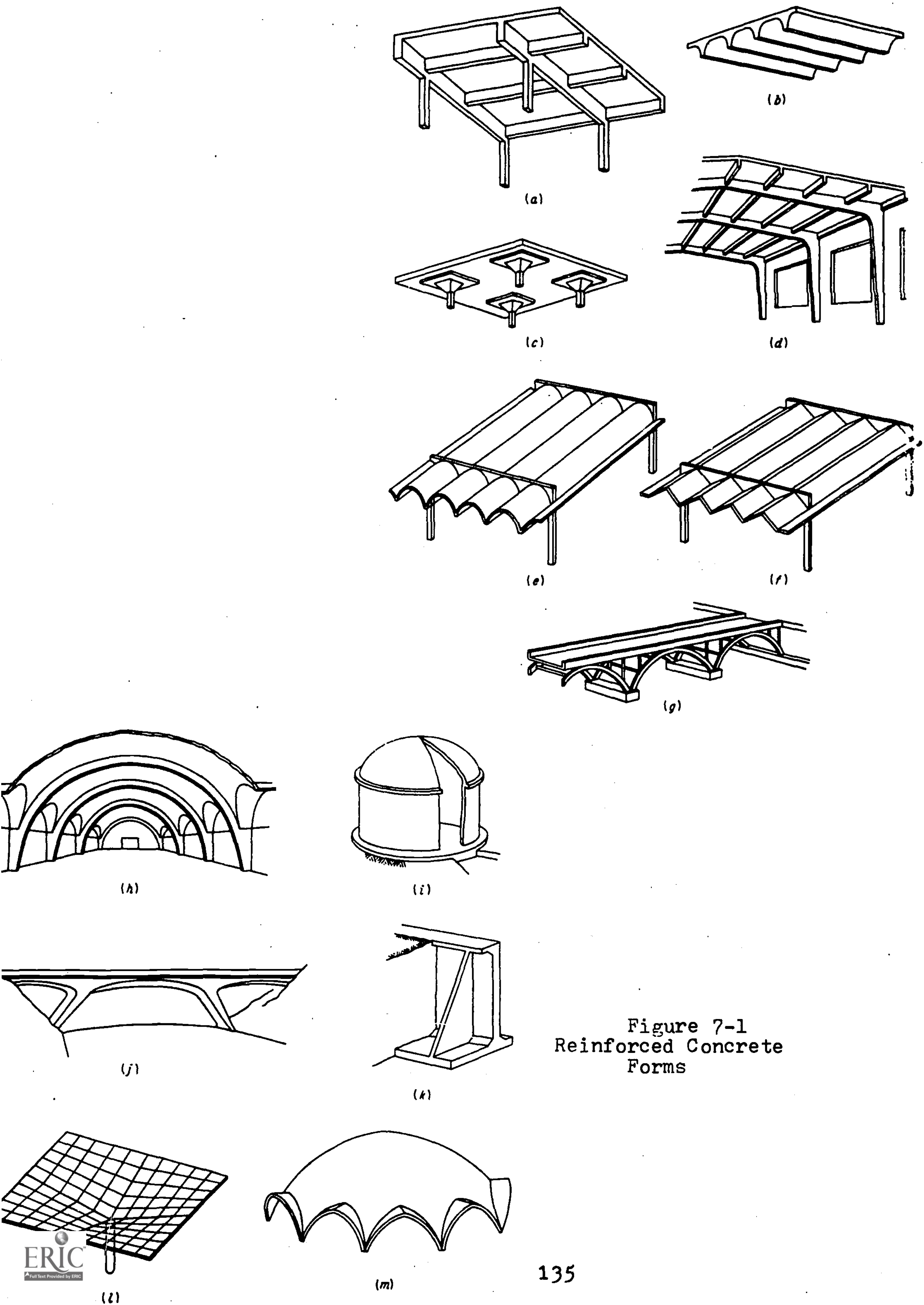


Figure 7-1
Reinforced Concrete
Forms

For making structural concrete, so-called hydraulic cements are used exclusively. Water is needed for the chemical process (hydration) in which the cement powder sets and hardens into one solid mass. Of the various hydraulic cements which have been developed, portland cement, which was first patented in England in 1824, is by far the most common.

Portland cement is a finely powdered, grayish material which consists chiefly of calcium and aluminum silicates. The common raw materials from which it is made are limestones, which provide CaO, and clays or shales, which furnish SiO_2 and Al_2O_3. These are ground, blended, fused to clinkers in a kiln, cooled, and ground to the required fineness. The material is shipped in bulk or in bags containing 94 lb of cement. Concretes made with portland cement generally need about two weeks to reach sufficient strength so that forms of beams and slabs can be removed and reasonsble loads applied; they reach their design strength after 28 days and continue to gain strength thereafter at a decreasing rate. To speed construction when needed, high-early-strength cements have been developed; they are more costly than ordinary portland cement, but reach, within 1 to 3 days, the strength a portland cement would have after 28 days. They have the same basic composition as portland cements, but are more carefully blended and more finely ground, both before and after clinkering.

When cement is mixed with water to form a soft paste, it gradually stiffens until it becomes a solid. This process is known as setting and hardening; the cement is said to have set when it has gained sufficient rigidity to support an arbitrarily defined pressure, after which it continues for a long time to harden, i.e., to gain further strength. The water in the paste dissolves material at the surfaces of the cement grains and forms a gel which gradually increases in volume and stiffness. This leads to a rapid stiffening of the paste 2 to 4 hours after water has been added to the cement. Hydration continues to proceed deeper into the cement grains, at decreasing speed, with continued stiffening and hardening of the mass. In ordinary concrete the cement is probably never completely hydrated. The gel structure of the hardened paste seems to be the chief reason for the volume changes which are caused in concrete by variations in moisture, such as the shrinkage of concrete as it dries.

For complete hydration of a given amount of cement, according to H. Rusch, an amount of water equal to about 25 per cent of that of cement, by weight, is needed chemically. An additional 10 to 15 per cent must be present, however, to provide mobility for the water in the cement paste during the hydration process so that it can reach the cement particles. This makes for a total minimum water-cement ratio of 0.35 to 0.40 by weight. This corresponds to 4 to 4.5 gal of water per sack of cement, the more customary way of expressing the water-cement ratio. Water-cement ratios in concretes are generally considerably larger than this minimum, to provide the necessary workability of the concrete mix. Any amount of water above the 25 per cent consumed in the chemical reaction produces pores in the cement paste. The strength of the hardened paste decreases in inverse proportion to the fraction of the total volume occupied by pores. Put differently, since only the solids, and not the voids, resist stress, strength increases directly as the fraction of the total volume occupied by the solids. This is why the strength of the cement paste depends primarily on, and decreases directly with, increasing water-cement ratio.

The chemical process involved in the setting and hardening liberates heat, known as heat of hydration. In large concrete masses, such as dams, this heat is dissipated very slowly and results in a temperature rise and volume expansion of the concrete during hydration, with subsequent cooling and contraction. To avoid the serious cracking and weakening which may result from this process, special measures must be taken for its control.

Aggregates. In ordinary structural concretes aggregates occupy about 70 to 75 per cent of the volume of the hardened mass. The remainder consists of hardened cement paste, uncombined water (i.e., water not involved in the hydration of the cement), and air voids. The latter two evidently do not contribute to the strength of the concrete. In general, the more densely the aggregate can be packed, the better are the strength, weather resistance, and economy of the concrete. For this reason the gradation of the particle sizes in the aggregate, to produce close packing, is of considerable importance. It is also important that the aggregate have good strength, durability, and weather resistance, that its surface be free from impurities such as loam, silt, and organic matter which may weaken the bond with the cement paste, and that no unfavorable chemical reaction take place between it and the cement.

Natural aggregates are generally classified as fine and coarse. Fine aggregate or sand is any material which will pass a No. 4 sieve, i.e., a sieve with four openings per linear inch. Material coarser than this is classified as coarse aggregate or gravel. When favorable gradation is desired, aggregates are separated by sieving into two or three size groups of sand and several size groups of coarse aggregate. These can then be combined according to grading charts to result in a densely packed aggregate. The maximum size of coarse aggregate in reinforced concrete is governed by the requirement that it shall easily fit into the forms and between the reinforcing bars. For this purpose it should not be larger than one-fifth of the narrowest dimension of the forms nor three-quarters of the minimum distance between reinforcing bars. Authoritative information on aggregate properties, their influence on concrete properties, and their determination, and on selection, preparation, and handling of aggregate is found in the report of ACI Committee 621.

The unit weight of so-called stone concrete, i.e., concrete with natural stone aggregate, varies from about 145 to 152 pcf and can generally be assumed as 150 pcf. For special purposes, lightweight concretes on the one hand and heavy concretes on the other are being used with increasing frequency.

Lightweight concrete can be obtained by gas-forming admixtures. However, in American practice they are almost universally produced by using special lightweight aggregates. The use of such concretes, if of strength equal to that of corresponding stone concrete, evidently reduces the dead loads of the structure. Also, the insulating properties of lightweight concrete are generally better than those of stone concrete, so that concretes of extremely light weight, whose strength may no longer be adequate for load-carrying purposes, are often employed as insulating fills.

A variety of lightweight aggregates is available. Natural materials, such as pumice and tuff, or by-products such as cinders, find some use without prior processing except for crushing and grinding. The majority of such aggregates, however, are produced artificially in kilns. Among them are expanded clays (haydite), shales, and slag and sintered fly ash. Some are used primarily for insulating purposes or masonry units; the heavier aggregates, such as expanded clays and shales, are suitable for lightweight structural concrete. Unit weights of lightweight concretes range from 30 to 80 pcf for insulating concrete, 65 to 100 pcf for masonry units, and 65 to 115 pcf for structural concrete. In general, the lower the weight, the lower the strength. The proportioning and control of lightweight aggregate mixes are more delicate than those of stone concrete and considerable care is needed to assure the desired properties.

Heavyweight concrete is frequently required for shielding against gamma and X radiation in nuclear-reactor and similar installations, for protective structures, and for special purposes, such as counterweights of lift bridges. Heavy aggregates are used for such concretes. These consist of heavy iron ores or barite (barium sulfate) rock crushed to suitable sizes. Steel in the form of scrap, punchings, or shot (as fines) is also used. Unit weights of heavyweight concretes with natural heavy rock aggregates range from about 200 to 230 pcf; if iron punchings are added to high-density ores, weights as high as 270 pcf are achieved. The weight may be as high as 330 pcf if ores are used for the fines only, and steel for the coarse aggregate.

Concrete consistency is most frequently measured by the slump test. A metal mold in the shape of a truncated cone 12 in. high is filled with fresh concrete in a carefully specified manner. Immediately upon being filled, the mold is lifted off, and the slump of the concrete is measured as the difference in height between the mold and the pile of concrete. The slump is a good measure of the total water content in the mix and should be kept as low as is compatible with workability. Slumps for concretes in building construction generally range from 2 to 6 inches.

In addition to the main components of concretes, admixtures are often used for special purposes. There are admixtures to improve workability, to accelerate or retard setting and hardening, to aid in curing, to improve durability, to add color, and to impart other properties. While the beneficial effects of some admixtures are well established, the claims of others should be viewed with caution. Air-entraining agents at present are the most important and most widely used admixtures. They cause the entrainment of air in the form of small, well-dispersed bubbles in the concrete. These improve workability and durability, chiefly resistance to freezing and thawing, and reduce segregation during placing. They decrease density because of the increased void ratio and thereby decrease strength; however, this decrease can be partially offset by reduction of mixing water without loss of workability. The chief use of air-entrained concretes is in pavements, but they are also used for structural work, particularly for outdoor structures.

Conveying, Placing, Compacting, Curing. Conveying of most building concrete from the mixer or truck to the form is done in wheelbarrows or buggies on horizontal runways or by pumping through steel pipelines. The chief danger during conveying is that of segregation. The individual components of concrete tend to segregate because of their dissimilarity. In overly wet concrete standing in containers or forms, the heavier gravel components tend to settle, and the lighter materials, particularly water, to rise. Lateral movement, such as flow within the forms, tends to separate the coarse gravel from the finer components of the mix. The danger of segregation has caused the discarding of some previously common means of conveying, such as chutes and conveyor belts, in favor of methods which minimize this tendency.

Placing is the process of transferring the fresh concrete from the conveying device to its final place in the forms. Prior to placing, loose rust must be removed from reinforcement, forms must be cleaned, and hardened surfaces of previous concrete lifts must be cleaned and treated appropriately. Placing and compacting are critical in their effect on the final quality of the concrete. Proper placement must avoid segregation, displacement of forms or of reinforcement in the forms, and poor bond between successive layers of concrete. Immediately upon placing, the concrete should be compacted by means of hand tools or vibrators. Such compacting prevents honeycombing, assures close contact with forms and reinforcement, and serves as partial remedy to possible prior segregation. Compacting is achieved by hand tamping with a variety of special tools, but now more commonly and successfully with high-frequency, power-driven vibrators. These are of the internal type, immersed in the concrete, or of the external type, attached to the forms. The former are preferable, but must be supplemented by the latter where narrow forms or other obstacles make immersion impossible.

Fresh concrete gains strength most rapidly during the first few days and weeks. Structural design is generally based on the 28-day strength, about 70 per cent of which is reached at the end of the first week after placing. The final concrete strength depends greatly on the conditions of moisture and temperature during this initial period. The maintenance of proper conditions during this time is known as curing. Thirty per cent of the strength or more can be lost by premature drying out of the concrete; similar amounts may be lost by permitting the concrete temperature to drop to 40°F or lower during the first few days unless the concrete is maintained continuously moist for a long time thereafter. Freezing of fresh concrete may reduce its strength by as much as 50 per cent.

To prevent such damage, concrete should be protected from loss of moisture for at least 7 days and, in more sensitive work, up to 14 days. When high-early-strength cements are used, curing periods can be cut in half. Curing can be achieved by keeping exposed surfaces continually wet through sprinkling, ponding, covering with wet burlap, or the like. Recent methods include the use of sealing compounds which, when properly used, form evaporation-retarding membranes, and waterproof papers. In addition to improved strength, proper moist curing provides better shrinkage control. To protect the concrete against low temperature during cold weather, the mixing of water and, occasionally, the aggregates are heated, temperature insulation is used where possible, and special admixtures, particularly calcium chloride, are employed. When air temperatures are very low, external heat may have to be supplied in addition to insulation.

Tests, Quality Control, Inspection. The quality of mill-produced materials, such as structural or reinforcing steel, is guaranteed by the producer, who must exercise systematic quality controls, usually specified by pertinent ASTM (American Society for Testing and Materials) standards. Concrete, in contrast, is produced at or close to the site, and its final qualities are affected by a number of factors which have been briefly discussed. Thus, systematic quality control must be instituted at the construction site.

The main measure of the structural quality of concrete is its compression strength. Tests for this property are made on cylindrical specimens of height equal to twice the diameter, usually 6 x 12 inches. Impervious molds of this shape are filled with concrete during the operation of placement as specified by ASTM C172, "Method of Sampling Fresh Concrete," and ASTM C31, "Method of Making and Curing Concrete Specimens in the Field." The cylinders are moist-cured at $70 \pm 5^{o}F$, generally for 28 days, and then tested in the laboratory at a specified rate of loading. The compression strength obtained from such tests is known as the cylinder strength f'_c and is the main property specified for design purposes.

To provide structural safety, continuous control is necessary to ensure that the strength of the concrete as furnished is in satisfactory agreement with the value called for by the designer. The "Building Code Requirements for Reinforced Concrete" of the American Concrete Institute, ACI 318-63 (henceforth referred to as the ACI Code), specify that a pair of cylinders shall be tested for each 150 yd^3 of concrete. It provides two degrees of control: (1) the average of any five consecutive pairs shall be at least equal to the specified design strength, and not more than 20 per cent of the pairs of tests may have values smaller than specified, and (2) the average of any three consecutive pairs shall be at least equal to the specified design strength, and not more than 10 per cent of the pairs of tests may have values smaller than the specified strength. These requirements provide for adequate average strength as well as for satisfactory uniformity. At the same time they recognize that it is not economically possible to manufacture concrete, or any other material, for that matter, without occasionally producing small quantities of somewhat substandard quality. The more advanced design methods known as <u>ultimate-strength design</u> may be used only when control conforms to the more rigorous requirements of (2), above, which also apply to prestressed concrete.

In spite of scientific advances, building in general and concrete making in particular, retain some elements of an art; they depend on many skills and imponderables. It is the task of systematic inspection to ensure close correspondence between plans and specifications and the finished structure. Inspection during construction should be carried out by a competent engineer, preferably the one who produced the design or one who is responsible to the design engineer. The inspector's main functions in regard to materials quality control are sampling, examination, and field testing of materials, control of concrete proportioning, inspection of batching, mixing, conveying, placing, compacting, and curing and supervision of preparation of specimens for laboratory tests. In addition, he must inspect foundations, formwork, placing of reinforcing steel, and other pertinent features of the general progress of work, keep records of all the inspected items, and prepare periodic reports. The importance of thorough inspection to the correctness and adequate quality of the finished structure cannot be emphasized too strongly.

<u>Reinforcing Steels</u>

a. <u>General</u>. As compared to concrete, steel is a high-strength material. The useful strength of ordinary reinforcing steels in tension as well as in compression, i.e., the yield strength, is of the order of 10 times the compression strength of common structural concrete, or of the order of 100 times its tensile strength. On the other hand, steel is a high-cost material as compared to concrete. It follows that the two materials are best used in combination if the concrete is made to resist the compression stresses, and the steel the tension stresses. Thus, in reinforced-concrete beams the concrete resists the compression force, longitudinal steel rods are located close to the tension face to resist the tension force, and frequently additional steel bars are so disposed that they resist the inclined tension stresses which are caused by the shear force in the webs of beams. However, reinforcement is also used for resisting compression forces, primarily where it is desired to reduce the cross-sectional dimensions of compression members, as in the lower-floor columns of multistory buildings. Even if no such necessity exists, a minimum amount of reinforcement is placed in all compression members to safeguard them against the effects of small accidental bending moments which might crack and even fail an unreinforced member.

For most effective reinforcing action, it is essential that steel and concrete deform together, i.e., that there be a sufficiently strong bond between the two materials so that no relative movements of the steel bars and the surrounding concrete occur. This bond is provided by the relatively large chemical adhesion which develops at the steel-concrete interface, by the natural roughness of the mill scale of hot-rolled reinforcing bars, and by the closely spaced rib-shaped surface deformations with which reinforcing bars are furnished in order to provide a high degree of interlocking of the two materials.

Additional features which make for the satisfactory joint performance of steel and concrete are the following: (1) The thermal expansion coefficients of the two materials, about 0.0000065 for steel vs. an average of 0.0000055 for concrete, are sufficiently close to forestall cracking and other undesirable effects of differential thermal deformations. (2) While the corrosion resistance of bare steel is poor, the concrete which surrounds the steel reinforcement provides excellent corrosion protection, minimizing corrosion problems and corresponding maintenance costs. (3) The fire resistance of unprotected steel is impaired by its high thermal conductivity and by the fact that its strength decreases sizably at high temperatures. Conversely, the thermal conductivity of concrete is relatively low. Thus damage caused by even prolonged fire exposure, if any, is generally limited to the outer layer of concrete, and a moderate amount of concrete cover provides sufficient thermal insulation for the embedded reinforcement.

b. Types of reinforcement. The most common type of reinforcing steel in reinforced (as distinct from prestressed) concrete is in the form of round bars. They are available in a large range of diameters, from about 1/4 in. to about 1 3/8 in. for ordinary applications, and in two recently developed heavy bars of about 1 3/4 in. and 2 1/4 in. These bars, with the exception of the 1/4-inch size, are furnished with surface deformations for the purpose of increasing the bond strength between steel and concrete.

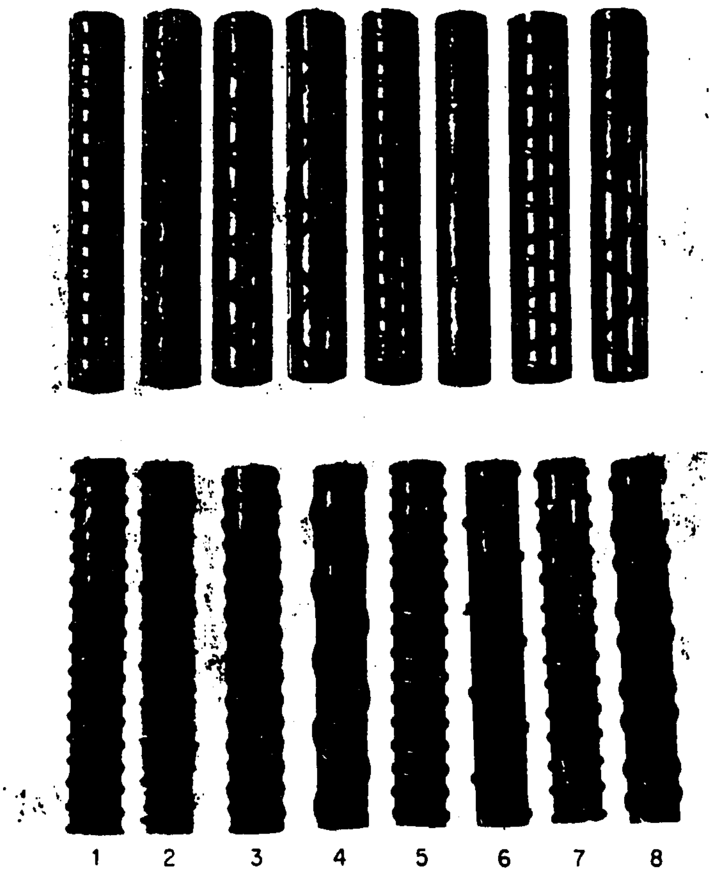


Figure 7-2 Types of Deformed Bars

c. Grades and strengths. Before the advent of prestressed concrete, almost the only grades of steel which were used for reinforcing bars were low-carbon steels with specified minimum yield points of 33 to 40 ksi and minimum tensile strengths of 55 to 70 ksi. Prestressing is most economical when reinforcement of very high strength is used; this brought into use the previously mentioned prestressing wires and strands, with yield strengths of 190 to 210 ksi and tensile strengths of 230 to 270 ksi. In very recent years, particularly with the advent of ultimate-strength design, deformed reinforcing bars made of higher-strength carbon steels as well as of low-alloy steels have become available, with specified minimum yield points from 50 to 75 ksi and tensile strengths from 80 to 100 ksi.

Minimum requirements for these deformations (spacing, projection, etc.) have been developed in lengthy experimental research and are specified in ASTM specification A305. Different bar producers use different patterns, all of which generally satisfy these requirements. Figure 7-2 shows a variety of current types of deformations (type 6 is no longer produced, since the spacing between its deformations exceeds the maximum specified value of 0.7 diam).

Bar sizes are designated by numbers, Nos. 2 through 11 being commonly used, and Nos. 14S and 18S representing the two special large-size bars previously mentioned. Designation by number, instead of by diameter, has been introduced because the surface deformations make it impossible to define a single easily measured value of the diameter. The numbers are so arranged that the unit in the number designation corresponds closely to 1/8 in. of diameter size. That is, a No. 5 bar has a nominal diameter of 5/8 in., and similarly for the other sizes.

Apart from single reinforcing bars, two other types of reinforcement are in common use for reinforcing slabs and other surfaces, such as shells. One of these is <u>welded steel wire fabric</u>. This consists of a series of longitudinal and transverse cold-drawn steel wires at right angles to each other and welded together at all points of intersection. Size and spacing of wires may be the same in both directions or may be different, depending on the requirements of the design. Detailed data can be found in commercial catalogues. A somewhat similar type is known as <u>bar</u> or <u>rod mats</u>. In these reinforcing bars or rods are used, instead of cold-drawn wire, to manufacture a grid of longitudinal and transverse bars, connected at their intersections either by welding or by clipping. For prestressed concrete, special forms and grades of reinforcement are used. The main types are <u>single prestressing wires</u>, with diameters ranging from 0.192 to 0.276 in., and <u>prestressing strands</u>. These are of the seven-wire type, having a center wire enclosed by six helically placed outer wires and ranging in nominal strand diameter from 1/4 in. to 1/2 in.

Table 7-1

Type	Grade	ASTM Specification No.	Specified Minimum Yield Point, ksi	Specified Minimum Tensile Strength, ksi
Billet or axle	Structural	A15 or A160	33	55
	Intermediate		40	70
	Hard		50	80
Rail	Regular	A16	50	80
	Hard		60	90
Billet	60-ksi yield	A432	60	90
Billet	High-strength	A431	75	100
Cold-drawn wire (e.g., for mesh)		A82	64	80

So-called intermediate-grade reinforcing steel with a specified yield point of 40 ksi is still the most prevalent, but it is being, and will increasingly be, displaced by reinforcing bars with 60 ksi yield point. The use of high-strength bars with 75 ksi yield point is so far limited by its higher cost and by the fact that, if used in flexural members, it requires special measures of deflection and concrete crack control; the latter is not yet completely understood and at this time is subject to intensive research relative to crack initiation and propagation. The higher-strength reinforcing bars are identified by the producers with rolled-in markings to prevent accidental substitution of the lower-strength intermediate-grade bars. Table 7-1 lists all presently available reinforcing steels, their designations, the ASTM specifications which define their properties in detail, and their two main minimum specified strength values.

The large-size bars No. 14S and 18S, whose properties are specified in ASTM A408, are available in the same three grades as the ASTM A15 steels.

CHAPTER VIII

WOOD CONSTRUCTION
(Light Framing)

There are four basic types of light wood framing in common use: Balloon, Braced, Western or Platform and Plank and Beam. Figures 8-1 through 8-6 illustrate methods of framing for the four types of structures including typical frame walls.

<u>Balloon Framing</u>. This type of structure consists of the supporting studs extended from the foundation to the eaves. A ribbon or ledger board is let into the studs to provide support for the floor joists.

Balloon type of framing is the outgrowth of our forefathers, when speed and economy were paramount, especially during pioneer days. With modifications over many years, it is yet a common type of light framing and is the only type of light building construction in which the studs extend from the foundation sill to the plate at the eaves. The long studs can be erected more rapidly and economically than the shorter studs used in either the Braced or Western framing. Where stucco finish is to be applied, cracks are less likely to occur when wall studs are continuous from foundation to eaves; the horizontal members at floor lines in other types provide more opportunity for vertical shrinkage and consequent stresses in the stucco surface.

Caution must be exercised by the designer and the inspector. The omission of floor headers and fire stops permits heat losses by free air circulation between studs and joists and permits fire to travel through the same areas. Elimination of corner braces reduces the structure's ability to resist torsion and impairs rigidity, unless sheathing is placed diagonally. Unequal settlement will result from resting partition studs on the subfloor.

<u>Braced Framing</u> was adapted from European design by early New England and Colonial builders. It is still a common type of framing. It has proven very satisfactory though it is more expensive to erect than the balloon type. It's characterized by separate story framing. Solid corner posts extend from the foundation to the eaves, with joists supported on heavy girts framed into the posts. Studs are cut in between the girts. Knee braces are provided at all corners at each floor level. This type of framing is rigid, strong and durable. There are historic dwellings in New England over 250 years old which are of this type of construction. The early construction was made of hand hewn

timber, mortise-and-tenon joints with wood dowels and pegs. Today our modern production and quality control of materials has led to a development of a more modified system and the perfecting of alternate types.

Western or Platform Framing. In this type of framing, the studs extend from the top of each tier of joists to the underside of the tier next above. The studs are erected with top and sole plates.

This type of construction is commonly referred to as Platform framing because the first floor is constructed on top of the foundation as though it were a platform, and the second floor on top in the same manner.

There is no hard and fast rule for designing and it is difficult to draw distinct lines between Balloon, Western or Braced framing, especially since these are modified by designs to suit special conditions and architectural effects. Each type has its advantages and disadvantages.

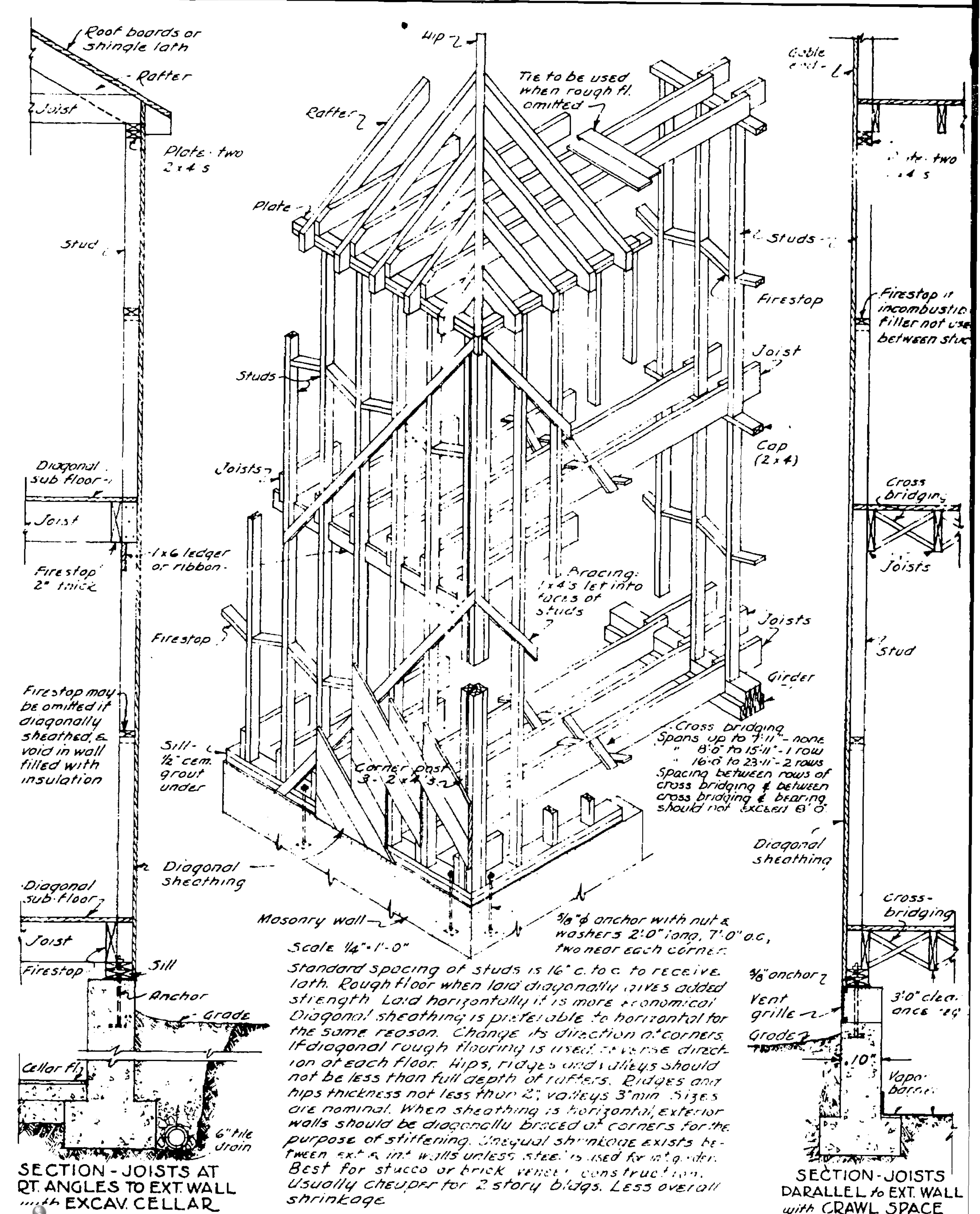
Plank and Beam Framing provides high ceiling effect with no increase in wall height, fewer structural members are required reducing labor costs, no cross bridging is required which reduces both material and labor costs. The exposed plank and beam ceiling provides architectural effect; however, consideration must be given to insulation. In most cases a rigid form of insulation is placed above the roof deck between the deck and the roofing material. Special consideration must be given to concealing wiring, duct work and plumbing. Particular care must be exercised to provide framing to support bath tubs, showers, stoves, refrigerators, etc., because of the span between floor joists. Bearing partitions and other heavy loads also require additional framing.

Usually standard lumber lengths are used (12, 14, & 16 feet lengths), and beams are spaced 6, 7 or 8 feet apart depending upon roof and floor loading. Two inch nominal thickness plank is used for subfloors and roof. Planks should be both blind and face nailed to the beam. This type of framing requires posts in lieu of studs to carry the loads, which are concentrated. Posts should never be less than 4 x 4 inches and could be larger depending upon the loads they carry. If built-up posts are used, they must be spiked together. Built-up beams must be securely spiked together from both outside faces. Beams spaced apart should be blocked at frequent intervals to prevent torsion and each beam nailed securely to the blocking.

Planks that butt over a single member should rest upon a beam width of three or more inches to provide adequate bearing and nailing surface for the planks. Where solid beams butt at a column, the column dimension should be 6 inches or greater parallel to the direction of the beam to provide proper bearing. If necessary, bearing blocks spiked to the column will increase bearing surface.

BALLOON FRAMING

FIGURE 8-1

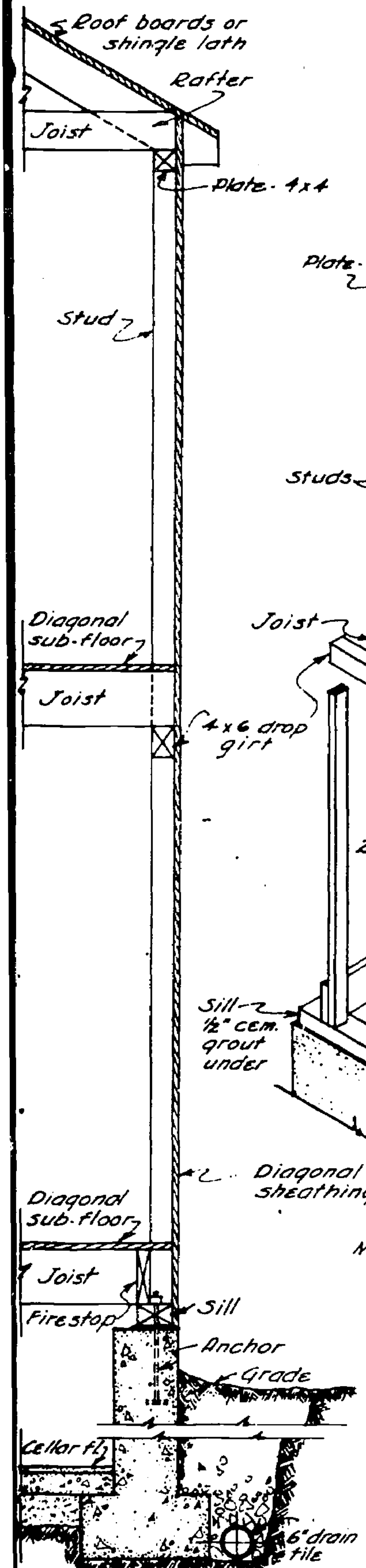


Standard spacing of studs is 16" c. to c. to receive lath. Rough floor when laid diagonally gives added strength. Laid horizontally it is more economical. Diagonal sheathing is preferable to horizontal for the same reason. Change its direction at corners. If diagonal rough flooring is used, reverse direction at each floor. Hips, ridges and valleys should not be less than full depth of rafters. Ridges and hips thickness not less than 2", valleys 3" min. Sizes are nominal. When sheathing is horizontal, exterior walls should be diagonally braced at corners for the purpose of stiffening. Unequal shrinkage exists between ext. & int. walls unless steel is used for int. girder. Best for stucco or brick veneer construction. Usually cheaper for 2 story bldgs. Less overall shrinkage.

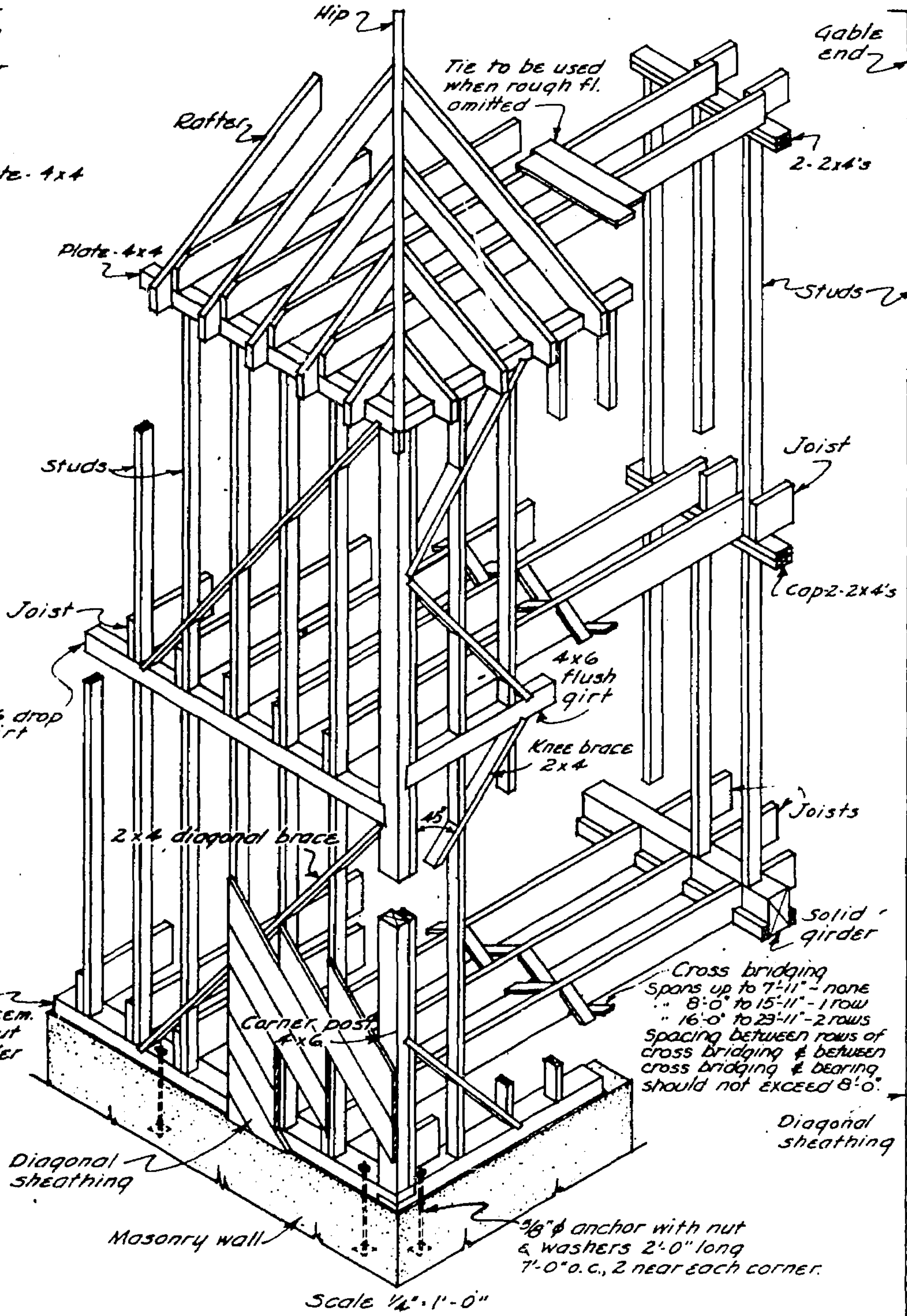
Adapted from data by the National Lumber Manufacturers Association

BRACED FRAMING

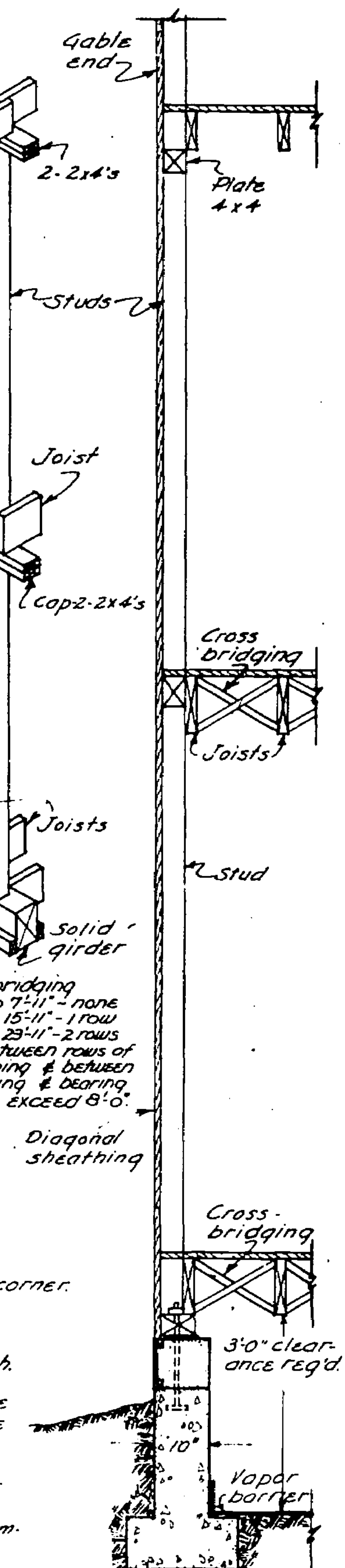
FIGURE 8-2



SECTION - JOISTS AT RT. ANGLES to EXT. WALL
" CAV. CELLAR
" = 1'-0"



Scale 1/4" = 1'-0"

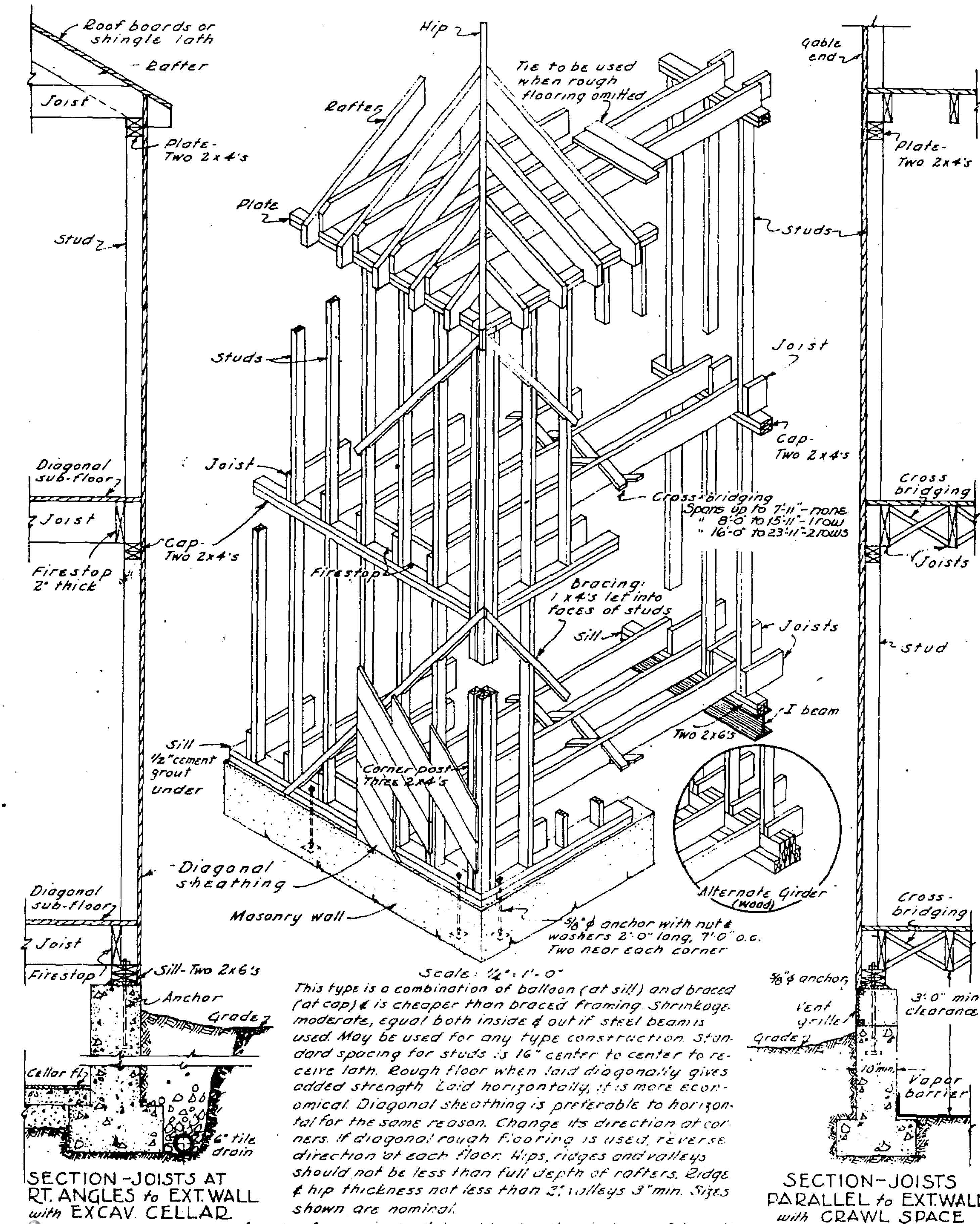


SECTION-JOISTS PARALLEL to EXT. WALL with CRAWL SPACE
3/8" = 1'-0"

Standard spacing of studs is 16" c. to c. to receive lath. Rough floor when laid diagonally gives added strength. Laid horizontally, it is more economical. Diagonal sheathing is preferable to horizontal for the same reason. Change direction of diagonal sheathing at each corner; change direction of diagonal rough flooring at each floor. Hips, ridges, & valleys should not be less than full depth of rafters. Ridge & hip thickness not less than 2"; valleys 3" min. Knee braces are resorted to when windows are too close to corner for full bracing. Sizes shown are nominal. Unequal shrinkage exists between exterior and interior walls, and total shrinkage is very great. This is the oldest & strongest type of framing. Not suitable for either stucco or brick veneer construction. It is difficult to run pipes up walls.

Adapted from data by National Lumber Manufacturers Association

FIGURE 8-3 MODERN BRACED FRAMING FIGURE 8-3



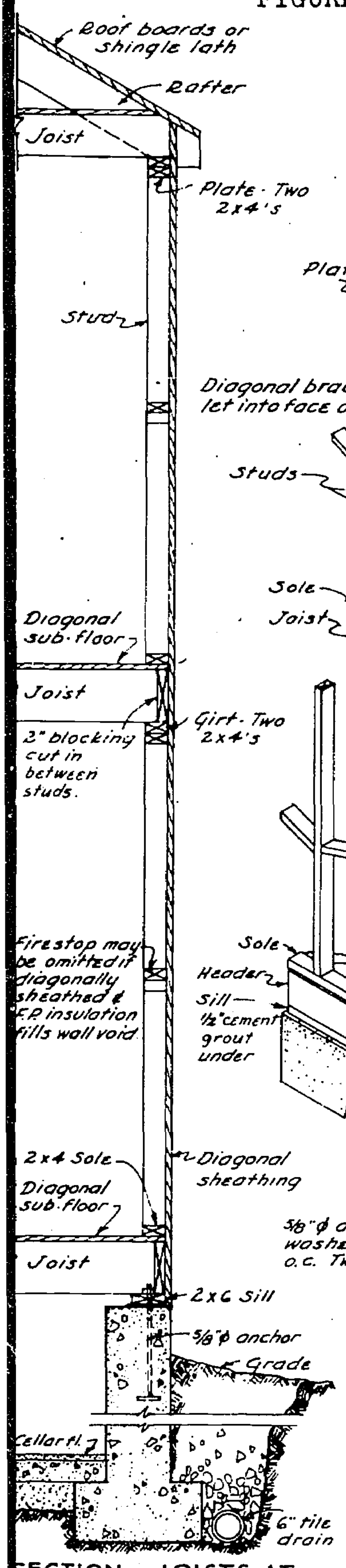
This type is a combination of balloon (at sill) and braced (at cap) & is cheaper than braced framing. Shrinkage moderate, equal both inside & out if steel beam is used. May be used for any type construction. Standard spacing for studs is 16" center to center to receive lath. Rough floor when laid diagonally gives added strength. Laid horizontally, it is more economical. Diagonal sheathing is preferable to horizontal for the same reason. Change its direction at corners. If diagonal rough flooring is used, reverse direction at each floor. Hips, ridges and valleys should not be less than full depth of rafters. Ridge & hip thickness not less than 2"; valleys 3" min. Sizes shown are nominal.

Adapted from data by National Lumber Manufacturers Association

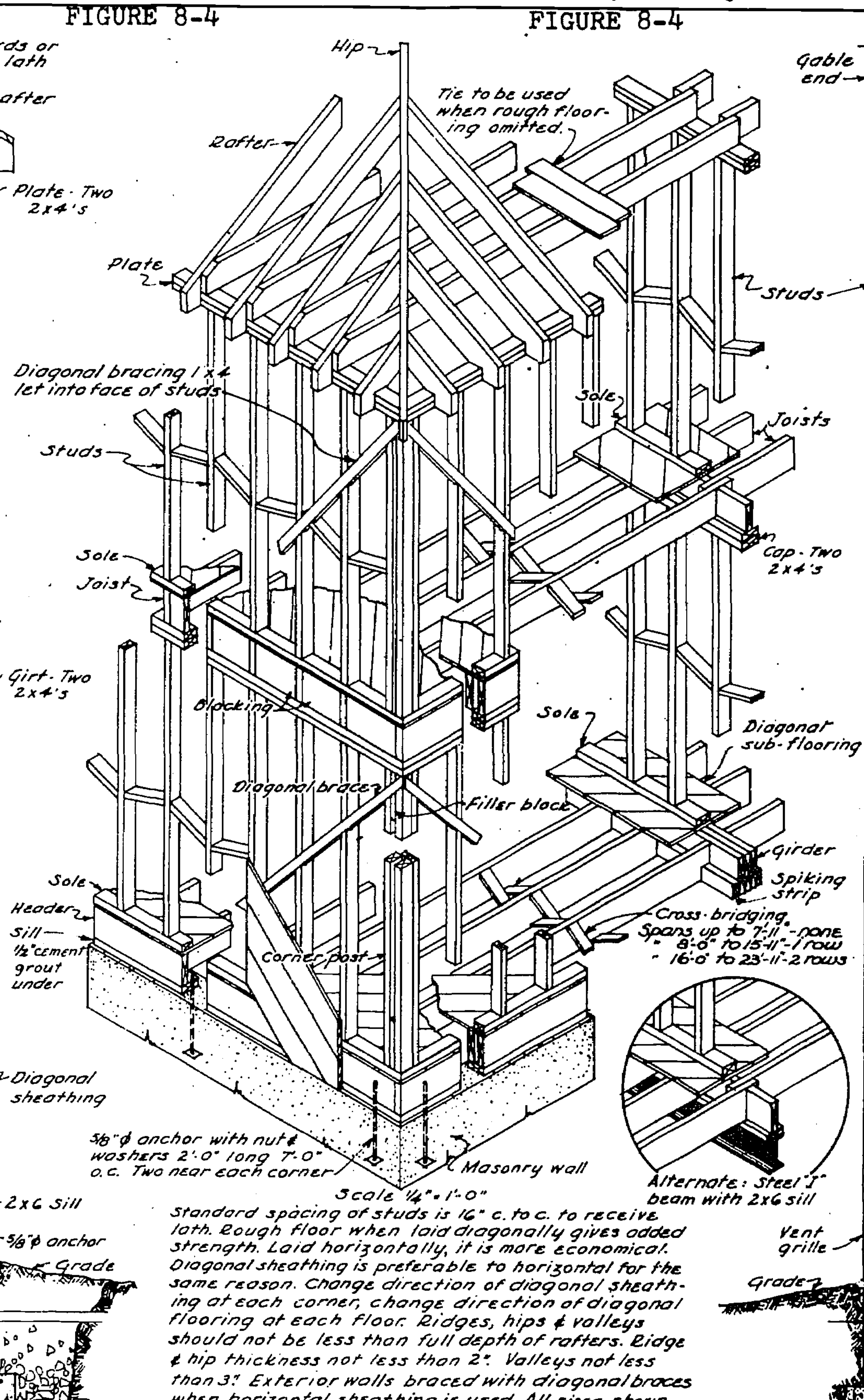
WESTERN (or PLATFORM) FRAMING

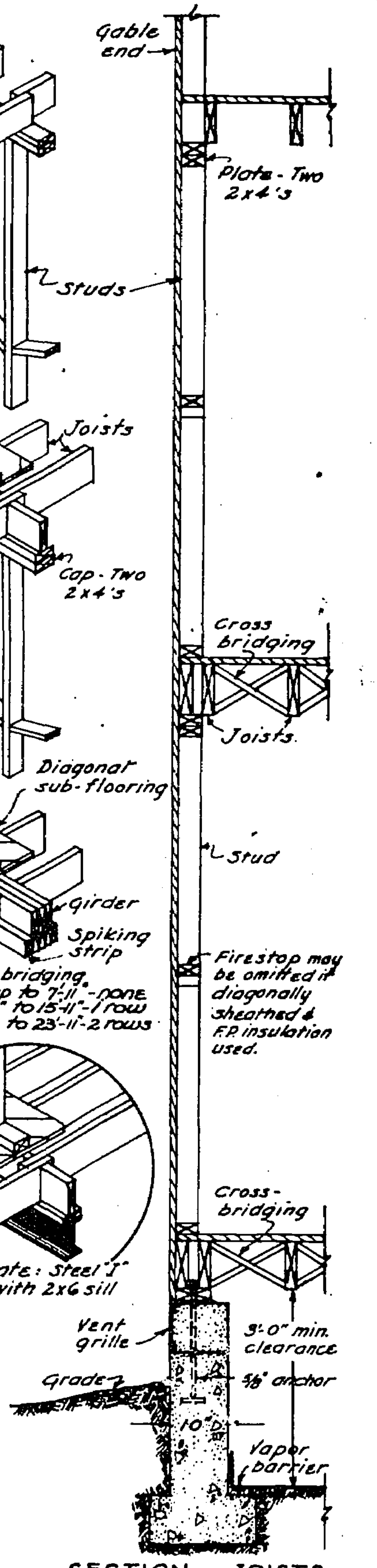
FIGURE 8-4

FIGURE 8-4



SECTION - JOISTS AT RT. ANGLES to EXT. WALL with EXCAV. CELLAR
" = 1'-0"



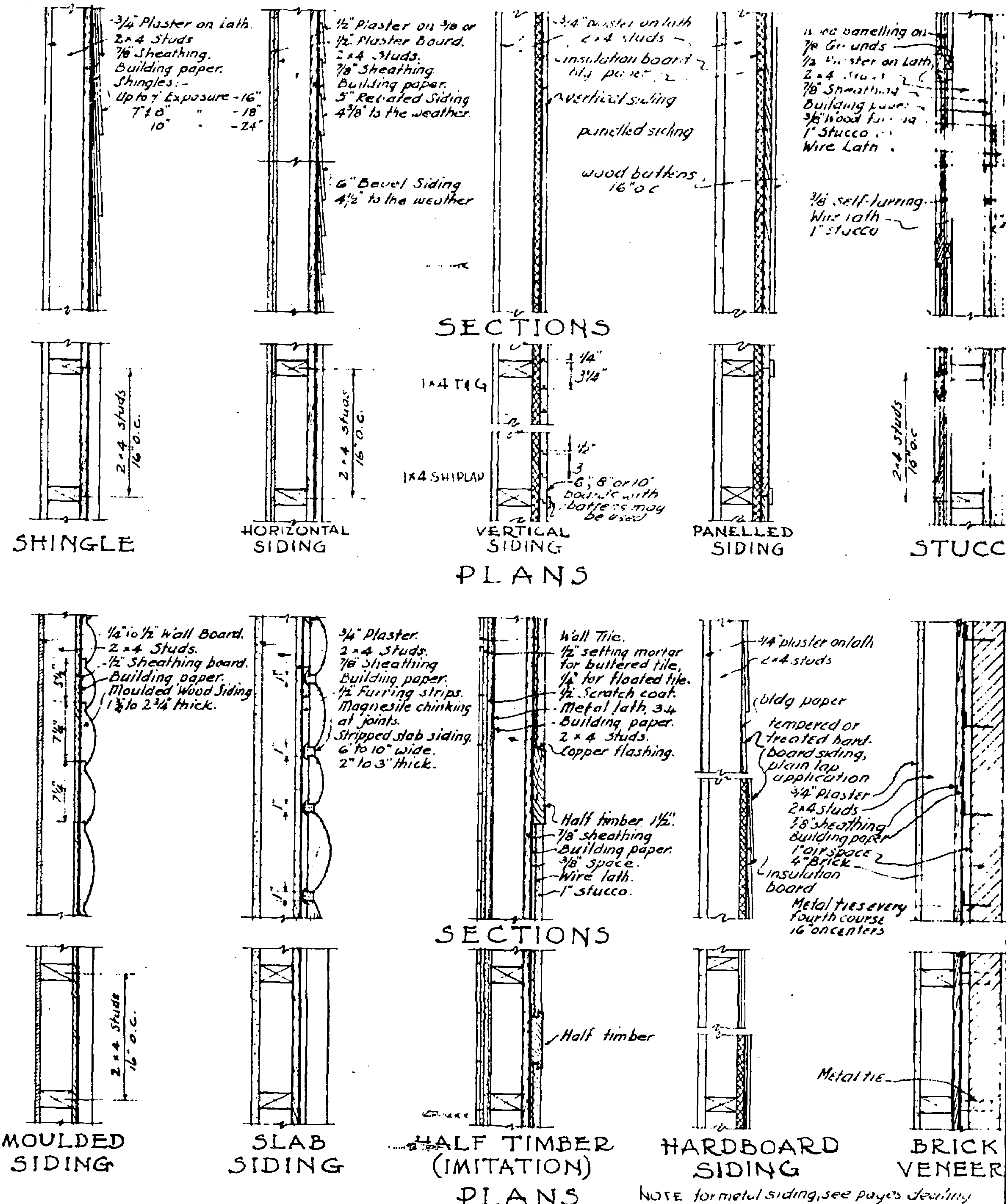


SECTION - JOISTS PARALLEL to EXT. WALL with CRAWL SPACE.
3/8" = 1'-0"

Standard spacing of studs is 16" c. to c. to receive lath. Rough floor when laid diagonally gives added strength. Laid horizontally, it is more economical. Diagonal sheathing is preferable to horizontal for the same reason. Change direction of diagonal sheathing at each corner, change direction of diagonal flooring at each floor. Ridges, hips & valleys should not be less than full depth of rafters. Ridge & hip thickness not less than 2". Valleys not less than 3". Exterior walls braced with diagonal braces when horizontal sheathing is used. All sizes shown are nominal. Equal shrinkage inside & outside. Large total shrinkage. Not recommended for stucco or brick veneer construction. Difficult to run pipes up walls. Good for 1 story buildings.

Adopted from data by National Lumber Manufacturers Association

FIGURE 8-5 FRAME WALLS FIGURE 8-5

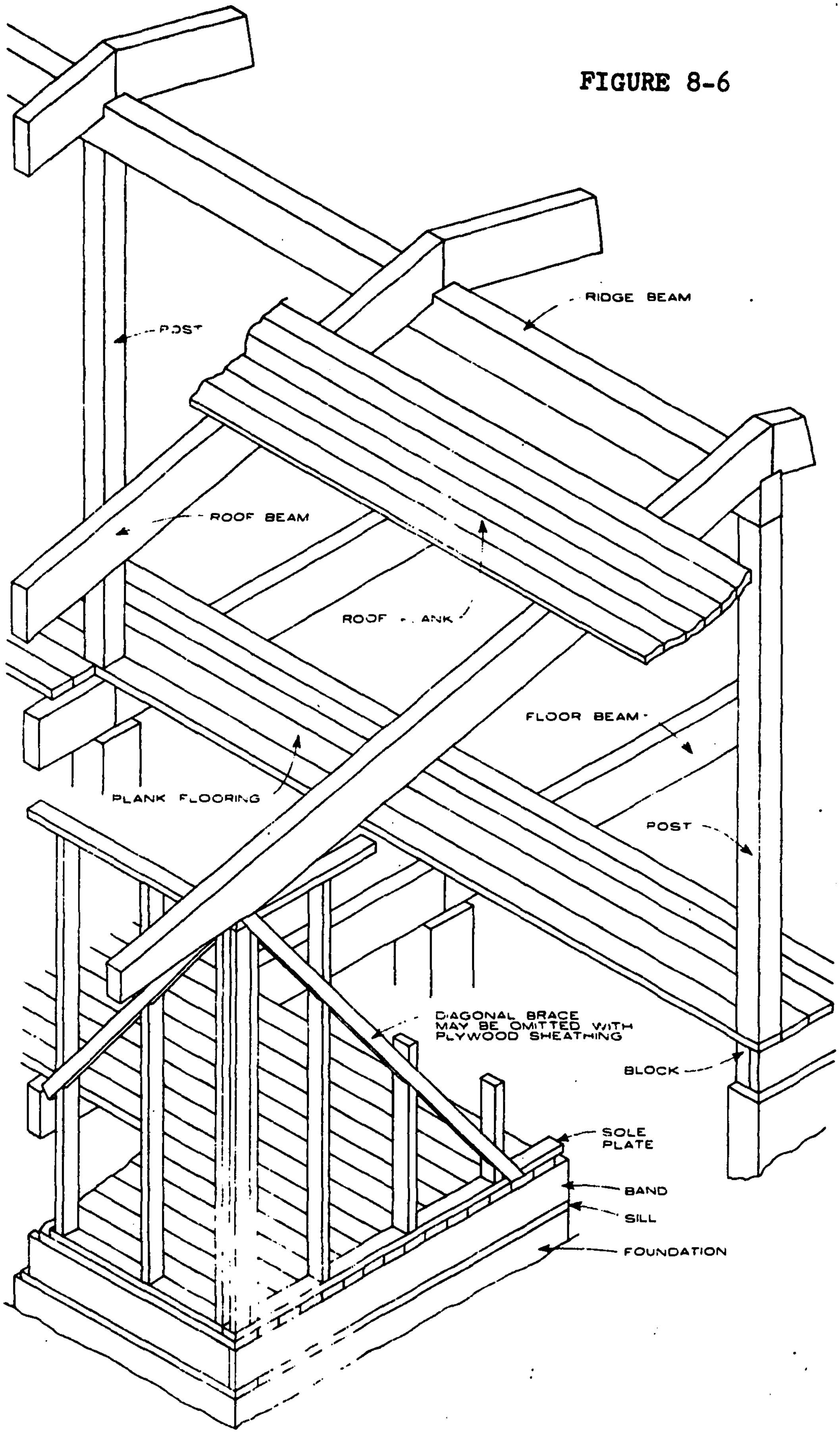


NOTE for metal siding, see pages dealing with specific material

Various interior ...es shown.

TYPICAL FRAME WALLS Scale 3/4" = 1'-0"

FIGURE 8-6



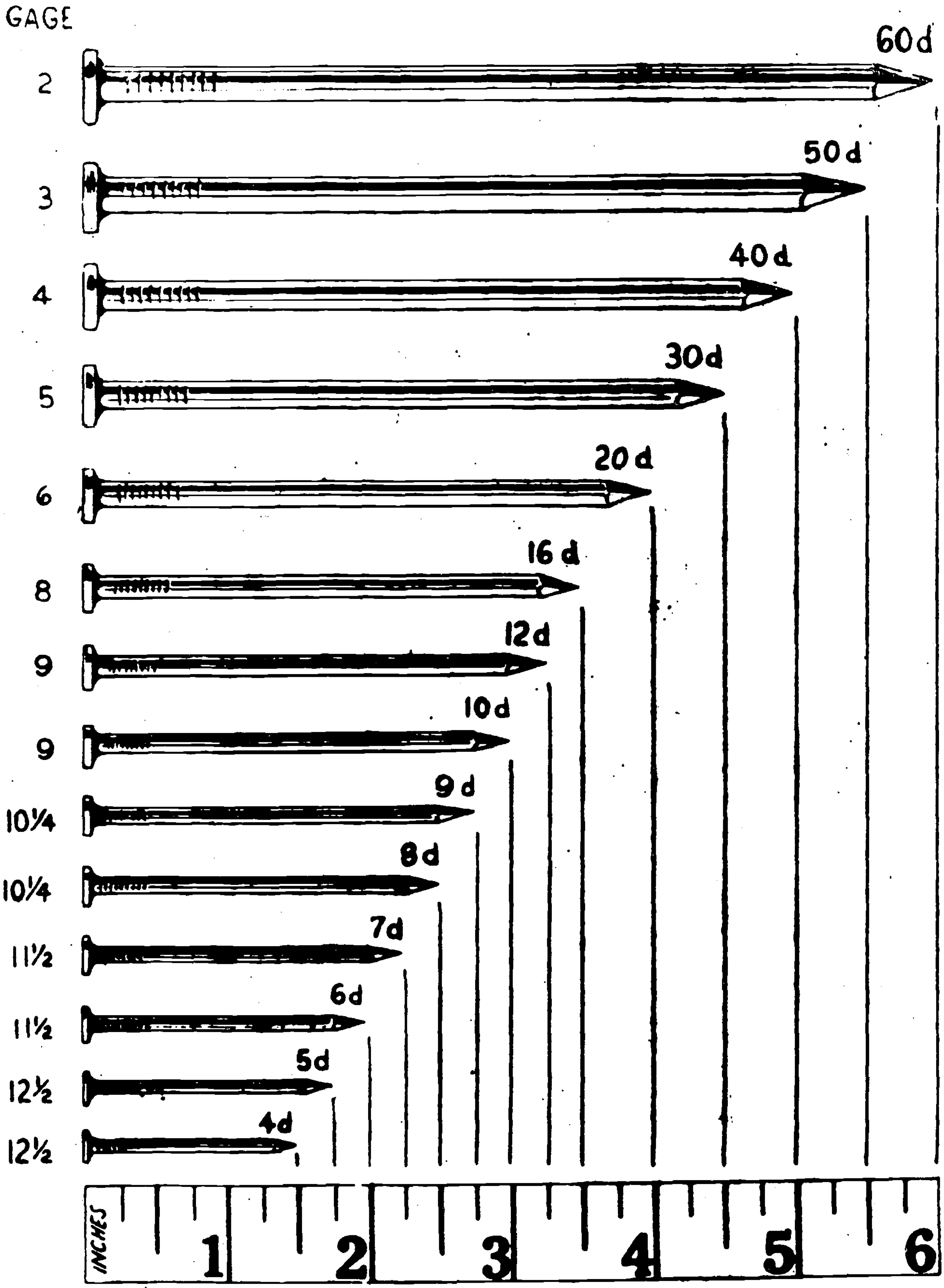
TYPICAL PLANK AND BEAM FRAMING FOR ONE STORY HOUSE

Joseph A. Wilkes, AIA; Wilkes and Faulkner, Washington, D. C.

RECOMMENDED NAILING SCHEDULE

Using Common Nails

Joist to sill or girder, toe nail	3-8d
Bridging to joist, toe nail each end	2-8d
Ledger strip	3-16d at each joist
1" x 6" subfloor or less to each joist, face nail	2-8d
Over 1" x 6" subfloor to each joist, face nail	3-8d
2" subfloor to joist or girder, blind and face nail	2-16d
Sole plate to joist or blocking, face nail	16d @ 16" oc
Top plate to stud, end nail	2-16d
Stud to sole plate, toe nail	4-8d
Doubled studs, face nail	16d @ 24" oc
Doubled top plates, face nail	16d @ 16" oc
Top plates, laps and intersections, face nail	2-16d
Continuous header, two pieces	16d @ 16" oc along each edge
Ceiling joists to plate, toe nail	3-8d
Continuous header to stud, toe nail	4-8d
Ceiling joists, laps over partitions, face nail	3-16d
Ceiling joists to parallel rafters, face nail	3-16d
Rafter to plate, toe nail	3-8d
1-inch brace to each stud and plate, face nail	2-8d
1" x 8" sheathing or less to each bearing, face nail	2-8d
Over 1" x 8" sheathing to each bearing, face nail	3-8d
Built-up corner studs	16d @ 24" oc
Built-up girders and beams	20d @ 32" oc along each edge



SIZES OF COMMON WIRE NAILS

CHAPTER IX

DRYWALL CONSTRUCTION

In the last two decades gypsum drywall construction has revolutionized the building industry. A dynamic expansion is taking place--to the point that today more than 75% of all new residential buildings have drywalls and ceilings and industrial buildings are swiftly following suit, especially in the administrative areas where quick occupancy and decor are desired.

<u>Drywall Construction</u> can be assembled into systems that offer specialized sound control and fire resistance, together with speed of installation, strength and low cost. The drywall system of construction and installation is becoming more widely accepted in commercial, industrial and institutional facilities.

<u>Gypsum</u> is a grey to white colored rock, a non-metallic mineral composed of calcium sulphate chemically combined with water of crystallization. This dry water makes up approximately 20% of the weight of gypsum rock.

The gypsum ore is mined or quarried, crushed, dried, ground to a flour fineness, and heated or calcined to drive off the greater part of the chemically combined water as steam. This calcined gypsum, or plaster of paris, is then mixed with water and other ingredients and sandwiched between two sheets of specially treated paper to form a ribbon of Sheetrock. After the gypsum core has set, the wallboard is cut to length, dried, pre-finished as required, and packaged for shipment.

<u>Fire Resistant</u>. Gypsum will not support combustion. Gypsum, when exposed to fire, behaves like a cake of ice when the flame from a blow torch is applied. It melts on the surface with the flame while the opposite side remains cool. Similarly, the surface of gypsum wallboard opposite the flame remains at a relatively low temperature until the gypsum core is completely calcined.

<u>Decoration</u>. The highly calendered face paper on wallboard is suitable for most any type of decorative treatment such as paint, texture or wallpaper and permits redecoration during the life of the structure. It also provides a bond for adhesives and a backing for wood panels.

Pre-Finished Panels are available which require no painting or joint finishing. Walls are complete as soon as panels are installed.

Speed of Erection. Drywall permits earlier completion of construction and earlier building occupancy.

Construction Practices. To obtain a good quality drywall job, skilled craftsmen correctly employing good construction practices are mandatory. The job must be planned in advance utilizing proper materials and tools. The best product on the market cannot be expected to produce the proper results if good construction practices are not followed by the applicators.

Framing Requirements. The framing to receive wallboard should be thoroughly inspected to be certain all previous trades such as rough in plumbing, electrical, etc., have been completed and in good order. Good framing, particularly wood, is essential regardless of the type of wall materials used.

Wood framing should meet the minimum requirements of FHA and local building codes. Failure to meet these requirements will materially increase the possibility of fastener failure due to wood shrinkage and warping.

Framing should approach as closely as possible the moisture content it will reach in service by allowing the building, after it is enclosed, to stand as long as possible prior to application of the wallboard.

Framing should be designed to account for shrinkage in wide dimensional lumber such as floor joists and headers. Wallboard surfaces may buckle or crack when firmly anchored across the flat grain of wide wood members as shrinkage occurs. With high exposed walls and cathedral type ceilings, regular or modified balloon framing should be used. With western or platform framing, the wallboard must either be floated over wood members or provided with a control joint at the joist location.

Framing Corrections. If joists are out of alignment, 2" x 6" leveling plates attached perpendicular to and across top of ceiling joists may be used. Toe nailing into joists pulls framing into true horizontal alignment and insures a smooth level ceiling construction.

Bowed or warped studs may be straightened by sawing the sides at the middle of the bow and driving a wedge into the saw kerf until the stud is in line. Reinforcement of the stud is accomplished by securely nailing 1" x 4" wood strips or "scabs" on each side of the cut.

Job Storage. Wallboard should be ordered for delivery a day in advance of drywall application. Materials stored on the job for a long period of time are subject to excessive abuse. Wallboard, like millwork, is a finished material to be handled with care to avoid damage.

The wallboard should be placed inside under cover and stacked on a clean floor in the centers of the largest rooms. It is often desirable to place the necessary number of pieces of wallboard in the location where they will be used. All materials on the job should remain in their wrappings or containers until ready for actual use.

Sheets planned for use on ceilings should be placed on top of the pile for removal first. Avoid stacking long lengths on top of short lengths as the weight of overhang of the longer board is apt to break the sheets. Avoid placing wallboard vertically against the framing with the long edge of the board horizontal. Even during application, vertical stacking tends to warp and deform the boards.

Caution should be exercised not to overload the framing members or the floor space when storing.

Wallboard should not be stored outside. There are so many variable conditions that, in general, outside storage of wallboard is not recommended.

Application of Wallboard.

1. Ceiling panels should be installed first.

2. Wallboard panels should be cut so as to slip into place easily.

3. All joints should be loosely butted together. Boards should never be forced into position.

4. Tapered edges, except at angles, should always be placed next to one another.

5. Butt ends should never be placed next to a tapered edge. (Wallboard is tapered and wrapped along the long dimension to facilitate joint treatment. Exposed ends (butts) along the short dimension are not tapered.)

Whenever possible, sheets should be applied horizontally and in lengths to span ceilings and walls without end (butt) joints. If butt joints occur, they should be staggered and located as far from the center of walls and ceilings as possible.

All ends and edges of wallboard and ceiling panels must be supported on framing members, except edges at right angles to framing in horizontal application and face layer of double-layer application and where end joints are to be set back-blocked and floated.

Back-blocking consists of laminating cut-to-size pieces of wallboard to the back surface of the wallboard directly behind the joints, providing reinforcement to resist stresses which cause ridging. Back-blocking long edge joints on wallboard is not required, but floating and back-blocking of all end joints on both sidewalls and ceilings is recommended.

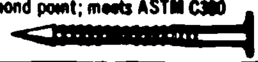
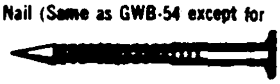
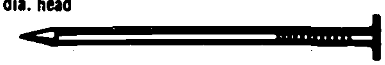
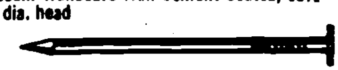
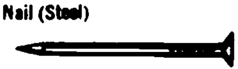
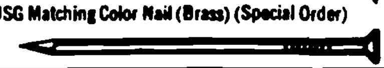
Single Layer Application. This basic construction is used to surface interior walls and ceilings not exposed to extreme or continuous moisture, and where economy and fast erection are required.

Double Layer Application consists of a face layer of wallboard applied to a base layer of the same material or a base layer of wood fiber or mineral fiber board that is directly attached to the framing members. This construction offers greater strength and higher resistance to fire and sound transmission. Walls and ceilings so constructed are highly resistant to cracking and easy to decorate. They minimize the possibility of fastener "pops" and discoloration over fastener heads.

Wallboard Nails have been vastly improved since the relationship of wood shrinkage to nail popping was discovered. Nails have been developed to concentrate maximum holding power over the shortest possible length--notably the annular ring type nail which has about 20% greater holding power than a cement-coated cooler type nail of the same length. However, under lengthy, extreme drying conditions, such as a cold dry winter, resulting wood shrinkage may cause fastener pops even with the annular ring nail.

As with screws, specification of the proper nail for each application is extremely important, particularly for fire-rated construction. Nails used in drywall construction should comply with performance standards adopted by the Gypsum Drywall Contractors International Gypsum Association and ASTM Specifications C380 or C514. The nails shown below comply with these performance standards.

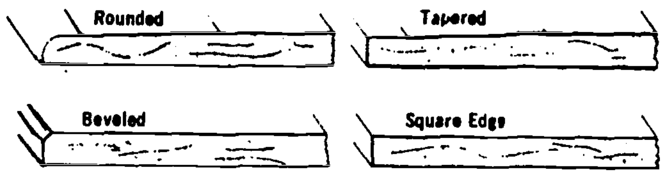
SELECTOR GUIDE FOR WALLBOARD NAILS

Fastening Applications	Fastener Description	Nail Spacing C. to C. (1)	Approx. Lbs. Nails Req'd per MSF SHEETROCK
½", ⅝" and ⅜" SHEETROCK Wallboard; ½" and ⅝" BAXBORD Gypsum Backing Board to wood frame (3)	1¼" GWB-54 Annular Ring Nail 12½ ga.; ¼" dia. head with a slight taper to a small fillet at shank; bright finish; medium diamond point; meets ASTM C380 	7" ceiling 8" walls	5¼
⅝" SHEETROCK Wallboard to wood frame (3)	1⅜" Annular Ring Nail (Same as GWB-54 except for length) 	7" ceiling 8" walls	5¼
⅝" SHEETROCK FIRECODE Wallboard face layers to staggered wood studs over ½" USG Wood Fiber Sound Deadening Board	2⅜" 7d Gypsum Wallboard Nail Cement Coated, 13 ga., ¼" dia. head 	7" walls (face layer)	9
⅜" and ¼" SHEETROCK Wallboard over existing surface, wood frame	1⅞" 6d Gypsum Wallboard Nail Cement Coated, 13 ga., ¼" dia. head 	7" ceiling 8" walls	6¼
⅝" SHEETROCK FIRECODE Wallboard to wood frame	1⅞" 6d Gypsum Wallboard Nail Cement Coated, 13 ga., ¼" dia. head 	6" ceiling 7" walls	6¾
½" SHEETROCK FIRECODE "C" Wallboard to wood frame	1⅝" 5d Gypsum Wallboard Nail Cement Coated, 13½ ga., 15/64" dia. head 	6" ceiling 7" walls	5¼
⅜" ULTRAWALL Panels —to wood frame (3) —over existing surface, wood frame (3)	1⅜" USG Matching Color Nail (Steel) 	8" walls	1½
	1⅞" USG Matching Color Nail (Steel) 	8" walls	4½
TEXTONE Vinyl Panels (17 finishes) to wood frame (3)	1⅜" USG Matching Color Nail (Brass) 	8" walls	2½
	1⅞" USG Matching Color Nail (Brass) (Special Order) 	8" walls	4½

NOTES: (1) Spacing shown are for single layer application without adhesive. (3) Nails shown for this application are also the proper size for use with adhesive.

TYPES OF SHEETROCK WALLBOARD

Types of Edges



Sheetrock is manufactured in the following sizes:

5/8" - Recommended for single layer drywall construction of industrial facilities and where greater resistance to fire exposure and transmission of sound are required.

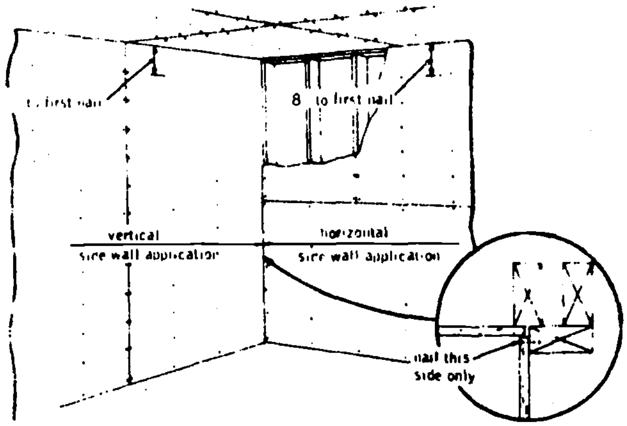
1/2" - For single layer application in new residential construction.

3/8" - Lightweight, applied principally in the double wall system and in repair and remodel work. Not recommended over metal framing.

Width - 4'; Length - 8', 9', 10', 12' or 14'

Tapered edge sheetrock has long edges tapered on the face side in order to form a shallow channel for the joint reinforcement which provides smooth, continuous wall and ceiling surfaces. In addition to the above sizes, tapered sheetrock also comes in 1/4", a lightweight, low cost, utility gypsum wallboard for use over old wall and ceiling surfaces. It is manufactured in 4' width and lengths of 8' and 10'. Edges are also tapered. It has an ivory manila paper finish, suitable for paint, wallpaper or other decoration.

FLOATING INTERIOR ANGLE APPLICATION



The floating interior angle method of applying gypsum wallboard effectively reduces angle cracking and nail pops resulting from stresses at intersections of walls and ceilings. Certain fasteners are eliminated at all interior angles, both where walls and ceilings meet and where sidewalls intersect.

Ceilings. Apply sheetrock wallboard to ceilings first. Follow standard framing practices for corner fastening. Fit wallboard snugly at all angles.

Horizontal Application - Use conventional single nail or screw application where end of board abuts a wall intersection. Where long edges of board are parallel with the intersection, apply the first nail or screw nominally 7" from wall. Use conventional fastening in remainder of ceiling area.

Vertical Application - Use conventional single nail or screw application where long edges of board abut a wall intersection. Where ends of board are parallel to an intersection, apply the first nail or screw nominally 7" from the wall. Use conventional fastening in the remainder of the ceiling area.

Sidewalls. Apply all wallboard to maintain firm contact at the ceiling line and to provide support to ceiling boards previously installed. Along the horizontal angle, apply the first nail or screw nominally 8" from ceiling intersection. At all vertical angles, omit only the corner fastening of the board that is first applied and overlapped in the angle. Nail or screw the overlapping board in conventional manner. Use conventional fastening in remainder of sidewall area.

Double Nailing. When double nailing is used with a floating interior angle, follow above spacing on first nail from intersection and use double nailing in rest of area. Conventional framing and ordinary wood back-up or blocking at vertical internal angles must be provided.

PROCEDURES FOR PROPER JOINT APPLICATION

Joint preparation. Check all nails by drawing a finishing knife across fasteners. Drive home protruding fasteners in board, leaving a dimple in surface paper of sheetrock wallboard. Using a broad steel finishing knife, butter joint compound into channel formed by tapered edges of sheetrock, filling channel fully and evenly. Avoid heavy fills which increase the possibility of excessive shrinkage and check cracking.

Embedding tape. Center the perforated tape reinforcement and press it down into the fresh joint compound. Holding knife at an approximate 45^{o} angle to the board, draw knife along joint with sufficient pressure to remove excess compound. Leave sufficient compound under tape for proper bond but not over 1/32" under the feathered edge. Do not use topping or finishing compound for embedding tape.

Covering tape. When tape is embedded, apply a skim coat of joint compound immediately after embedding. This skim coat reduces possibility of edge wrinkling or curling which may lead to edge cracking. Allow to dry completely.

Spotting fastener heads. Immediately prior to or after embedding tape, apply first coat of compound over all fastener heads. Use pressure on knife to finish compound level with the wall surface. Spot fastener in a similar manner during second coat application of compound. During application of third coat over joints, sand fastener heads lightly and apply third finishing coat over fastener heads. Allow compound over fastener heads to completely dry. Light sanding should be performed before decorating.

Second coat application to joints. After embedding and covering coat is completely dry (under good conditions usually 24 hours), apply second coat, feathered approximately two inches beyond edges of first coat. Spot fastener heads with a second coat application of compound, allow to dry.

Third coat application. After second coat is dry, sand lightly. Apply a thin "finishing" coat to joints and fastener heads. Feather joint edges at least two inches beyond second coat. Sand lightly when dry.

End joints. Butt or end joints are treated the same as tapered joints. When sheetrock is applied, end joints should be loosely butted together. Fill joint with compound to a point slightly above the surface of boards to allow for shrinkage in drying. Apply additional compound along each side of joint and embed tape as described in tapered joints. Apply second and third coats in same manner as for tapered joints. Finishing coats of joint compound must be feathered wider (approximately 18") because there is no taper in which to embed tape.

Mechanical tool application performs the same function as described above. Hand touch up and spotting by hand are required.

METAL STUD PARTITIONS

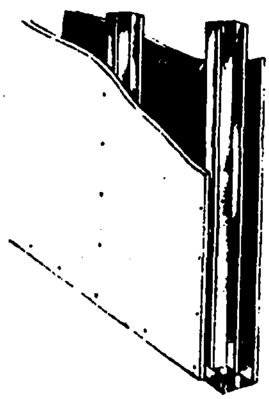
These are light weight, non-load bearing assemblies. Speedy erection, fire and sound resisting properties are prime considerations of Architects and Engineers for their use. They consist of steel channel studs, set in floor and ceiling runner tracks and faced each side with one or two layers of sheetrock gypsum wallboard, screw attached. Screw heads and joints are finished with joint treatment described above.

Studs, available in four widths, are used with 1/2" or 5/8" sheetrock wallboard facings applied horizontally or vertically depending upon job layout, sound and fire resistance required.

Maximum stud spacing 24" o.c. Limiting heights: 1 5/8" metal studs, 9'; 2 1/2" stud, 12'; 3 5/8" stud, 16'; 4" stud, 17' 3".

Single Layer - Metal Stud Partition

These versatile systems offer a practical method of partitioning for corridors, or within units. Screw fasteners assure positive attachment of wallboard, freedom from nail "pops".



INSPECTION

Schedule of Inspection.

Make job inspections at the following stages:

A. When drywall materials are shipped to the job, (1) verify material meets specifications and approvals, (2) check for proper storage of materials. Damaged material should not be used.

B. When framing is erected but before wallboard application.

C. When base layer is applied; when face layer is applied.

D. When joints are treated, (1) during taping and first coat application, and (2) during second coat application.

E. When job is completed.

Installation Inspection.

Job inspection should include the installation of all materials with particular attention directed to the following items:

Framing

1. Check accuracy of alignment and position of framing according to plans or details.

2. See that partitions are straight and true; ceilings level.

3. Measure spacing of studs and joists. Spacing should not exceed maximum allowable for the system.

4. Verify that there is caulking beneath runners, if required.

5. Look for protrusions of blocking, bridging, or piping, and twisted studs and joists that would create an uneven surface. Correct situation before wallboard attachment.

6. Make sure there is appropriate blocking and support for fixtures and wallboard.

7. Measure the moisture content of wood framing with a moisture meter. Delay wallboard application until moisture content is 15% or less.

8. Check to see that window and door frames, electrical and plumbing fixtures are set for the wallboard thickness used.

9. Check for proper position and attachment method of Resilient Channels.

10. Review all wood framing for compliance with minimum framing requirements.

11. Examine metal studs at corners, intersections, terminals, door and light frames for positive attachment to floor and ceiling runners.

12. Inspect spliced metal studs for proper assembly.

13. See that door and light frames are securely attached to stud and runner rough framing at all anchor clips.

14. Look for spot grouting at door and light frames.

Suspended Grillage

1. Measure spacing of hangers, channels and studs to see that they are within allowable limits.

2. Check ends of main runner and furring channels. They should not be let into or supported by abutting walls, and should extend to within 6" of the wall to support a furring channel.

3. Make sure furring channel clips are alternated and that furring channel splices are properly made.

4. See that mechanical equipment is independently supported and does not depend upon the grillage for support.

5. Inspect construction around light fixtures and openings to see that recommended reinforced channel support is provided.

Base Layer

1. Verify that material being used complies with the specifications and fire or sound test construction.

2. Make sure the proper type of application is being used, horizontal or vertical application, and that joints are staggered.

3. Check for cracked and damaged edge board. These should not be used.

4. See that the recommended fastener is being used and measure the spacing of fasteners.

5. Check caulking for proper seal behind electrical boxes, medicine cabinets, etc.

6. Inspect installation to make sure insulating wool blankets are adequately attached and properly fitted.

7. Review appropriate system construction and application, and inspect for compliance with laminating recommendations and other construction procedures.

Face Layer

1. Verify material compliance.

2. Look for high quality workmanship. Cracked or damaged edge board should not be used. Wallboard surfaces should be free of defects; joints correctly butted and staggered.

3. Check proper application method--horizontal or vertical.

4. Examine fasteners for compliance with specifications, and measure the spacing of fasteners.

5. Review adhesive application method and see that manufacturer's recommendations and specifications are being followed.

6. Inspect trim at corners and around partition perimeter for secure attachment and proper installation.

7. Make sure that caulking is applied where required and completely seals the void.

8. Review back-blocking installation to be sure correct procedure is followed.

Fasteners

1. Make sure recommended or specified fasteners are used.

2. See that fasteners are applied starting in the center of the wallboard and working to the ends and edges.

3. Observe whether the board is held tightly against the framing. Test for loose board by pushing adjacent to the fastener. Check to see that the face paper is not broken when fastener is driven. If necessary, a second fastener should be driven within 1½" of the faulty one.

4. Examine fastener positions. Fasteners should be at least 3/8" in from edges and ends.

Adhesives

1. See that adhesive is applied only to clean, dry surfaces.

2. Make sure that board is erected within the allowable time limit after adhesive is applied so proper bond can be obtained.

3. Measure size of bead and spacing. Check for correct shape.

4. Observe impacting blows for proper spacing and positioning.

5. Make sure temporary fastening and shoring holds board tightly in place.

6. Review the appropriate adhesive application methods and inspect for compliance.

Joint Treatment

1. Make sure wallboard surface is ready for joint treatment. Fastener heads should be properly seated below wallboard surface. Protrusions should be sanded below level of surface. Cracks between panels should be filled with joint compound before taping.

2. See that recommended mixing directions are followed. Only clean water and mixing equipment should be used. Joint compounds should not be held over or retempered.

3. Some joint compounds can be used almost immediately after mixing. Make sure that directions are followed closely both for mixing and application.

4. Inspect joints and corners to see that the tape is properly embedded and covered promptly with a thin coat of joint compound. Only compounds suitable for embedding should be used. Heavy fills should be avoided.

5. Make sure that compound is used at its heaviest workable consistency and not over-thinned with water.

6. Check to see that joint compound is allowed to dry thoroughly between coats.

7. Inspect second and third coats over joints for smoothness and for proper edge feathering. Only compatible compounds should be used over Durabond compound.

8. Examine fastener heads and metal trim to see they are completely covered.

9. See that all finished joints are smooth and dry before decoration. Sand smooth if necessary.

Temperature

In cold weather, see that temperatures between 55° and 70°F are maintained both day and night. This temperature should be maintained 24 hours before, during and after the entire wallboard and joint treatment application.

Ventilation

Check for proper ventilation to provide drying of joint compound in about 24 hours. Avoid drafts during hot dry weather that cause too rapid drying of compound.

Special Applications

Review installation recommendations for special applications such as back-blocking, floating angle, predecorated board.

CHAPTER X

LATHING AND PLASTERING

Two grades of workmanship are commonly used in specifying the quality of work required, which in turn influence the cost. They are:

1. Ordinary workmanship which permits surfaces, grounds, corners, etc., to vary from a true work plane by as much as 1/8 to 3/16 inches, and

2. First Grade workmanship which requires that all workmanship be true and level, both horizontally and vertically and finishes must not vary by more than 1/32 to 1/16 inches.

LATHING

Plaster is applied to both masonry and prepared lath surfaces. The masonry surfaces usually consist of block, brick, stone, tile, etc. The prepared lath surfaces fall into three major categories:

1. Wood lath
2. Metal lath
    a. Wire lath
    b. Sheet metal
    c. Perforated sheet lath
    d. Self-furring or ribbed lath
3. Gypsum and fiber lath

Wood lath sizes most commonly used are 1/4 or 3/8 inch thick, 1 or 1 1/2 inches wide and 32 or 48 inches long. The wood lath is nailed to studs or furring strips spaced 16 inches on centers, with 1/4 to 3/8 inch spacing between laths to permit plaster keys.

NOTE: Wood lath must be thoroughly soaked and saturated with water prior to the application of plaster; otherwise, the wood lath will swell and crack the plaster.

Metal lath has replaced wood lath almost entirely. Metal lath is secured to wood studs as well as metal studs. When fastened to wood studs, staples or large head roofing nails are used; also, common nails are driven part way into the stud and bent over the metal lath. Nails are usually spaced approximately 8 inches apart. Sheets of metal lath are applied with length perpendicular to the supports. Side laps should be at least 1 inch, with two strands of No. 18 gauge soft wire tieing them together with spacing of approximately 6 inches. End laps should be at least 1 1/2 inches; again using wire to lace the adjacent sheets together.

Metal lath on steel studs is usually installed for fire resistant plastered partition walls. The metal lath is applied on both sides of a lightweight 3/4 inch steel channel with a total thickness of approximately 2 1/2 inches. Steel channels are spaced 12 to 16 inches on centers which serve as studs and are anchored top and bottom. Metal lath is attached using wire at 6 inches spacing. The sides and ends are lapped 1 and 1 1/2 inches respectively.

Gypsum board lath is one of the more popular types of plaster base. It is used on walls or ceilings (see Fig 9.1-1). It is 16 x 48 inches and is applied horizontally or across framing members. It has a paper face with a gypsum filler. For stud or joist spacing of 16 inches on center, 3/8 inch thickness is required. For 24 inches on center spacing, 1/2 inch thickness is required. This material can be obtained with a foil back that serves as a vapor barrier. It is also obtainable with perforations (see Fig 9.1-3). The perforations improve the bond by permitting the plaster to key into the openings thus causing the plaster to remain intact for a longer period of time in the event of fire. Most building codes require perforated gypsum lath for that reason.

Insulated fiberboard (Fig 9.1-2) is normally available in 1/2 inch thick and 18 by 48 inches and has a shiplap edge. This board may be installed using metal clips that are located between studs or joists to stiffen horizontal joints. Insulated fiberboard, or fiberboard lath is used as an insulation in many instances. It is used on walls and ceilings.

Expanded metal lath (Fig 9.1-4) is sheet metal cut and expanded to form many small openings to permit plaster to key into it. Any metal used as a plaster base should be galvanized or treated to prevent rust and deterioration. The minimum weights for 16 inch stud or joist spacing are:

Use	Pounds per Sq Yd
Walls	2.5
Ceilings	3.4
Ceilings (with Flat Rib)	2.75

Metal lath normally is available in 27 x 96 inches in size.

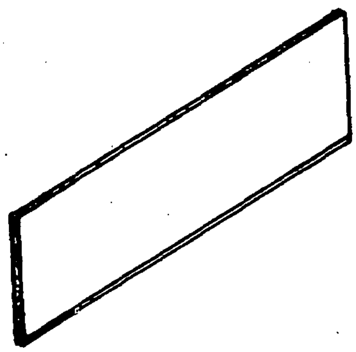


FIGURE 9.1-1

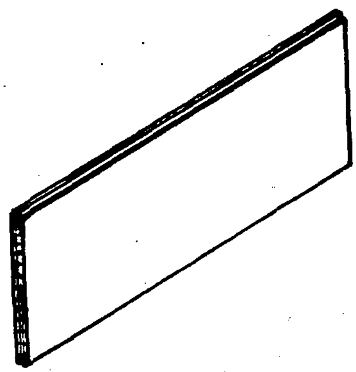


FIGURE 9.1-2

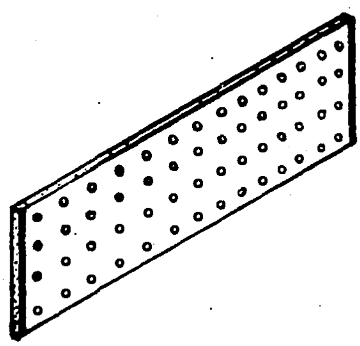


FIGURE 9.1-3

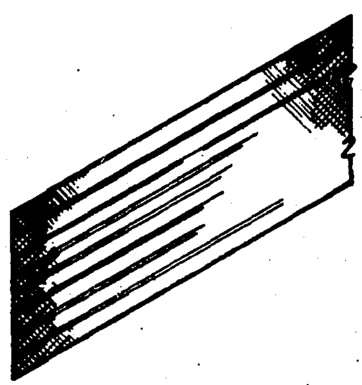


FIGURE 9.1-4

PLASTERING MATERIALS AND APPLICATION

The term plaster finish pertains to interiors. When used for exterior it is called stucco. The plaster for interior finishing is made of combinations of lime, gypsum plaster, sand, cement and prepared special waterproof finish wall material (Keene's Cement) which should be used in areas subjected to excessive moisture such as bathrooms, especially in showers, etc.

Plaster is applied in one, two or three coats, depending on the base to which it is to be applied and the specification requirements. The minimum thickness over a lath or masonry base should be 1/2 inch. The first coat over wood or metal lath is called the scratch coat and is usually 1/4 inch thick. This term comes from the requirement to scratch the first coat after a slight set has occurred to insure a better bond for the second coat. The second coat is called the brown coat or leveling coat and is normally 3/8 to 1/2 inch thick. Since this is the course that determines the quality of workmanship for level and plumb, it is usually the thickest.

The final or finish coat, also referred to as the "White Coat" consists of two general types, the sand float and the putty finish. The sand float finish consists of sand and lime which results in a textured finish, the texture depending on the coarseness of the sand used. The putty finish is used without sand and results in a smooth finish which is normally required for enamel or gloss surface treatment. Finish coat is usually 1/16 inch to 1/8 inch thick and a steel trowel is used to obtain the smooth hard surface.

VENEER PLASTERING SPECIFICATIONS (From Lathing and Plastering Reference Specifications, California Lathing and Plastering Contractors' Association, Inc)

(See following Pages)

9. VENEER PLASTERING

9.1 DESCRIPTION

9.1.1 Veneer Plaster Construction.—Shall consist of large size gypsum lath attached to wood or metal supports as specified, and which shall receive a thin overall monolithic plaster coating (finish) applied in one or more coats to a thickness of one-sixteenth inch (1/16") to one-eighth inch (1/8"). Minimum overall thickness of lath and veneer plaster shall be one-half inch (1/2").

9.2 LATHING MATERIALS (1)

9.2.1 Gauges of Wire (See 2.2.2)

9.2.2 Nails & Staples (See 2.2.3)

9.2.3 Power Driven Staples (See 2.2.31)

9.2.4 Nailing Channels (See 2.3.4)

9.2.5 Screw Channels (See 2.3.5)

9.2.6 Nailable Studs nlb (See 2.4.2)

9.2.7 Screw Studs nlb (See 2.4.3)

9.2.8 Structural Nailable Studs lb (See 2.5.1)

9.2.81 Runner Track (See 2.5.2)

9.2.82 Bridging (See 2.5.3)

9.3 GYPSUM LATH

9.3.1 General.—Gypsum lath shall conform to the Standard Specifications for Gypsum Lath—ASTM Designation C-37."

9.3.11 Types of Lath.—Gypsum lath for veneer plaster shall be plain, (or) Type "X", (or) insulating, gypsum lath as specified herein, or as dictated by fire resistance requirements. Face side of lath shall have a special paper designed for application of veneer plaster. (2) (3) (4)

9.3.12 Dimension of Lath.—Gypsum lath for veneer plaster systems shall meet the following nominal dimensional requirements:

Thickness: 3/8", 1/2", or 5/8" (greater thickness may be used)
Width: 48" (Width may vary slightly to meet job requirements)
Length: 96" or longer to meet job requirements

9.4 ACCESSORIES

9.4.1 General.—Metal shapes used as grounds for veneer plaster shall be of such a size as to provide for required thickness.

9.4.2 Corner Beads. For use at all external corners shall be formed of minimum .015 inch thick zinc coated steel, or other approved material, having minimum seven-eighth inch (7/8") wings, with minimum three-eighth inch (3/8") diameter holes.

9.4.3 Casings.—Used to provide a finished edge at window and door jambs, at openings, at partition terminals, and at intersections with other materials; shall be formed of minimum .015 inch thick zinc coated steel, or other approved material.

9.4.4 Partition Bases.—Recessed, flush type, or reveal type base for veneer plaster partitions or other walls, shall be formed of minimum No. 26 gauge steel, galvanized or coated with a rust inhibiting paint. Clips and splice plates shall be the manufacturer's regular type for the base used.

(1) Paragraphs 9.2.1 through 9.2.82 cover metal framing materials which can be used to construct metal partitions and walls, or ceiling grillages to which veneer lath and plaster are applied.

(2) See 2.7.2.

(3) Type "X" (special fire retardant) designates gypsum lath for veneer plaster complying with these specifications, that provides fire retardant ratings at least equal to those obtained with the same thickness of Type "X" gypsum wallboard, when tested in accordance with the requirements of the Method of Fire Tests of Building Construction and Materials (ASTM Designation: E-119).

(4) Consult manufacturers for independent test data on assembly particulars, materials, and ratings for specific type of construction.

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9.4.5 Joint Reinforcement.—Strip reinforcement used to reinforce joints of lath base for veneer plaster shall be glass fiber mesh a minimum width of two inches (2"); or perforated cross fibered paper tape, or other approved material of equal strength. (5)

9.4.6 Asbestos Tape.—For use on horizontal wood supports in certain fire rated ceiling assemblies shall be 8 lb. commercial grade asbestos paper .018 inch thick.

9.4.7 Metal Trim Staples.—Staples to secure corner beads or casings shall be flattened (galvanized) steel wire with minimum nine-sixteenth (9/16") legs; for securing joint reinforcement mesh, leg length shall be minimum one-quarter inch (1/4").

9.5 PLASTERING MATERIAL

9.5.1 Veneer Plasters.—Shall be a proprietary specially formulated high-strength gypsum base plaster for hand or machine application to large size lath or other properly prepared surfaces. Veneer plaster shall be formulated for application as a thin monolithic basecoat plaster over which a finish may be applied, or may be formulated for application as a finish plaster. It shall have a setting time of from twenty to ninety minutes and a minimum compressive strength of 1500 psi. Setting time of plaster shall be controlled at the time of manufacture, or by introduction of, or contact with a setting agent, as recommended by the manufacturer.

9.5.2 Standard Plaster Finishes.—For application over veneer basecoat plaster shall be gypsum-lime smooth finish, (or) Keene's Cement-Lime float finish (or) machine dash finish; or approved manufactured regular gypsum finishes. (6)

9.5.3 Water.—For mixing with veneer plaster shall be clean, fresh, suitable for domestic consumption, and free from such amounts of mineral or organic substances as would affect the set of the plaster.

9.5.4 Bonding Agent.—(See 6.10). (7)

9.6 METAL FRAMING (8)

9.6.1 Metal Framing Members.—Shall be straight, true, and properly aligned so that plane of lath at edges and ends is not offset.

Where metal studs extend above suspended ceilings each stud shall be securely attached to a horizontal three-quarter inch (3/4") channel placed above the ceiling and along the full length of the partition.

9.7 WOOD FRAMING (by others) (9) (10)

9.8 LATH ERECTION AND APPLICATION

9.8.1 Application of Large Size Lath.—Apply large size lath for veneer plaster in either a vertical or horizontal direction. All ends and edges of the lath shall fall on supports except when edge joints are at right angles to supports.

On wood frame construction apply lath first to the ceiling and then to walls. On metal framing lath may be applied in any sequence. Fit ends and edges of lath as close together as permitted by framing, but do not force into place. At external corners butt and fit lath so as to provide solid corner. Stagger end joints when lath is applied across supports. Place joints on opposite sides of partitions on different supports. Wherever possible, do not place joints at corners of door and window frames.

(5) Other types of material may be used to reinforce joints in lath and to strengthen plaster over joints provided it is approved by the architect and the Building Department which has jurisdiction.

(6) See 7.4.22; 7.4.23; 7.4.24; 7.4.25.

(7) Bonding agents are sometimes used to bond veneer plaster to concrete or masonry interior surfaces. Use only on recommendation of manufacturer.

(8) For erection of metal studs and ceiling grillage, see Specification Reference No. 3; or consult manufacturer.

(9) Wood framing by others should meet the minimum requirements of FHA and local building codes. Framing member should be straight, true, of uniform dimension, and properly aligned, and should have a moisture content not in excess of 15% at the time of the gypsum large size lath application. Bowed or twisted studs or joists should be straightened by others.

(10) For spacing of supports for large size lath see Table 5.9.

Attach lath from center to edges and ends, pressing the lath firmly against the supports. Place attachments approximately three-eighth inch (3/8") from edges of lath. Set attachment flush with the surface of the lath but do not break paper.

Internal vertical and horizontal angles on wood frame construction may be floated by not attaching lath to the supports in the angles; where supports are at right angles to the internal angle, attach lath approximately eight inches (8") away from angle.

Cut lath to fit electrical outlets, pipes or other required openings.

9.8.2 Application of Joint Reinforcement.—Apply joint reinforcement to all joints either by stapling or by embedding in veneer plaster as recommended by manufacturer. Do not overlap reinforcement at intersections. Secure joint reinforcement by one of the following methods:

Stapling: Staple reinforcement at ends on each side of joint and at maximum twenty-four inch (24") intervals along reinforcement on alternate sides of joint. Staple reinforcement on one side only of vertical angles, and on ceiling side only of horizontal angles. (11)

Embedding: Embed reinforcement mesh or tape in veneer plaster at all joints before application of base or finish coat. If finish plaster is to be machine applied, plaster at joints shall be free of trowel marks or ridges. (11)

(11) Where a fire rated assembly is specified the joint treatment should be as specified by the manufacturer of the veneer plaster system.

9.8.3 Application of Accessories.—Install corner beads at all external angles, set tight against lath and attach by nail, staple or by crimping. Attach accessories at not more than twelve inch (12") intervals. (12) (13)

(12) Approved adhesives may also be used.

(13) Where other metal trim is required for protection of edges at windows and openings and at intersections with other materials, etc., so indicate on drawings.

9.9 VENEER PLASTERING

9.9.1 Mixing.—Mix veneer plaster in strict conformity with recommendations of manufacturer.

9.9.2 Application.—Apply veneer plaster by hand or machine to a minimum thickness of one-sixteenth inch (1/16") as directed by manufacturer, and as required to achieve the specified finish. Finish shall be (a) smooth, (b) trowel texture, (c) spray texture, as indicated on drawings or on room finish schedule. (14) (15)

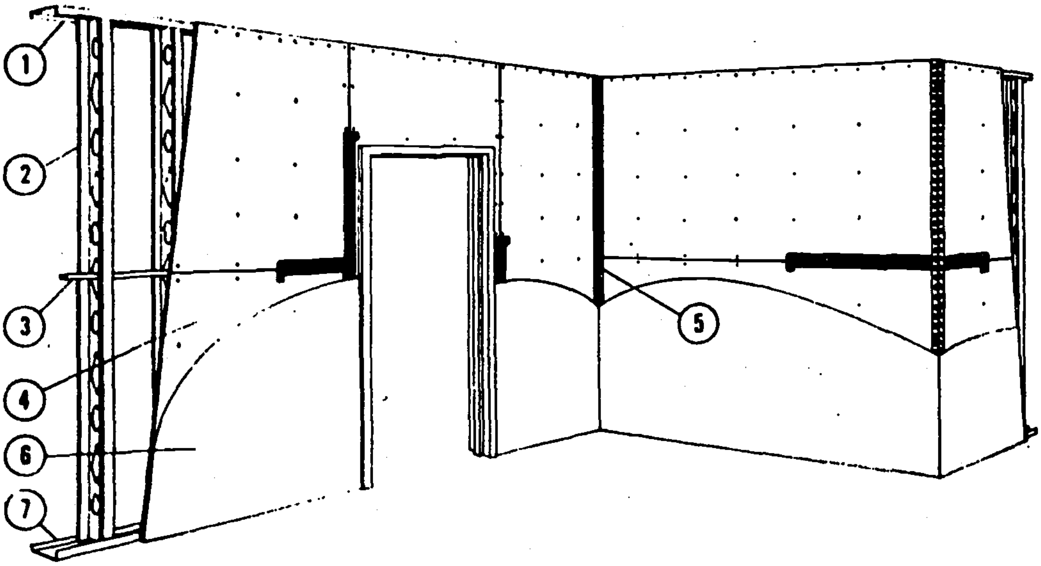
(14) Specify finish treatment required. Machine applied textures are light stipple (sand finishes); depth of trowel texture is limited by thickness of veneer plaster.

(15) When acoustic-type texture (non-rated) finish is applied over veneer plaster on ceilings prior to plastering lath on walls, the wall lath should be protected from overspray so as not to affect bond and setting time of plaster.

DETAIL 50

VENEER PLASTER

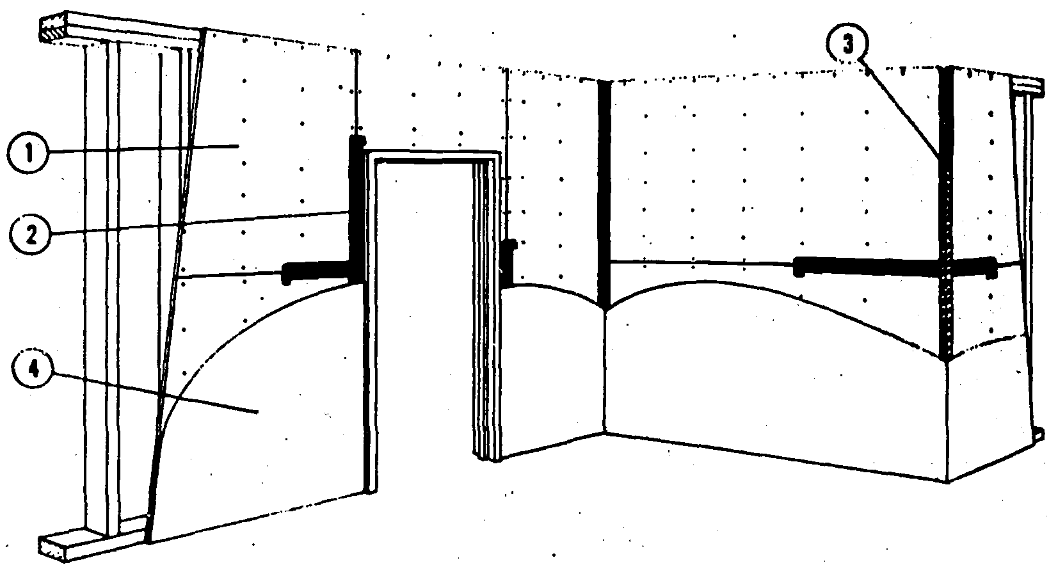
For Veneer Plaster Construction See Specification Reference 9



(1) Ceiling Runner Track
(2) Metal Stud (nailable or screw)
(3) Horizontal Stiffener[1]
(4) Large Size Lath
(5) Joint Reinforcement
(6) Veneer Plaster (1/16 to 1/8 inch thick)
(7) Floor Runner Track

[1] Stiffener is omitted with screw studs.

(A) METAL STUD CONSTRUCTION



(1) Large Size Lath
(2) Joint Reinforcement
(3) Corner Bead
(4) Veneer Plaster (1/16 to 1/8 inch thick)

(B) WOOD STUD CONSTRUCTION

CHAPTER XI

ROOFS AND ROOFING MATERIAL

Roofs are not only designed to protect the interior of structures from the elements, they also provide the Architect an opportunity to present a functional as well as an attractive structure. Figure 10-1 shows some of the common types of roofs.

The simplest form of roof is the shed or lean-to, and, as its name implies, is used for small sheds, porches or small buildings. It has only one slope.

The saw-tooth roof is a development of the shed or lean-to roof and is essentially a series of lean-to roofs covering one building. This type of roof is used primarily in industrial buildings because of the additional light it provides through windows on the vertical sides.

The gable or pitched roof is the most commonly used. It is simple and efficient. It is a triangular section, having two slopes meeting at the center or ridge and forms a gable. It is economical and easy to construct.

The hip roof is formed of four straight sides sloping toward the center of the building, terminating in a ridge. The pyramid roof is a modification of the hip roof in which the four straight sides sloping toward the center terminate in a point instead of a ridge.

The hip-and-valley roof gets its name because hip-and-valley rafters are required in its construction. There are many modifications of this roof.

The double-gable roof is a modification of a gable or a hip-and-valley roof in which the extension has two gables, forming at its end an M shape.

The ogee roof has a pyramidal form with steep sides sloping to the center, each side being ogee shaped, that is, lying in a compound hollow and round curve.

The conical roof, or spire, is a steep roof of circular section which tapers uniformly, forming a circular base to a central point.

The gambrel roof was probably developed from the simple gable by breaking the roof surface near the middle on either side of the building. The portion of the roof below the break was made steeper, while that portion above the break was flattened out. The gambrel roof has a kind of gable at each end of the building.

The mansard roof, although somewhat similar to the gambrel roof, slopes from each wall toward the center instead of from only two opposite walls, as in the case of the gambrel roof. The surface sloping up from each wall plate is nearly vertical and as a result the upper surface is quite flat.

The french or concave mansard roof is a modification of the mansard roof -- its sides being concave instead of straight.

The gambrel and mansard roofs both place smaller thrusts on the side walls. They do provide greater attic space, although are frequently used simply to provide a different architectural effect.

Roof coverings are many and varied. The more common types are: wood shingle, slate, tile, asphalt composition shingle, roll roofing, aluminum, galvanized steel and sometimes sheet copper although its cost is almost prohibitive now.

The type of roof covering, roof loading and degree of insulation establish the type of roof deck to be installed, i.e. for slate, tile and for other heavy roofings, plywood, wood sheathing, tongue-and-grooved boards, ship-lap boards, etc. are generally used. The use of roof lath or nailing strips, 1 inch thick by 2 or 3 inches wide in place of solid deck is prevelant in certain locations.

The selection of roof coverings depends upon a number of considerations; but, other things being equal, the designer usually prefers the use of wood shingles on homes and small buildings and built-up asphalt roofing on flat roofs of industrial buildings.

Shingles-shingle shakes are selected as a roof covering for three principal reasons: (1) they are easily handled, (2) they have a long life expectancy and will outlive many of the other ordinary forms of roofing, and (3) for their esthetic value.

In the early days, wooden shingles were rived from blocks of wood and were known as shakes. They were rough and of the same thickness at both ends. An improvement was the shaved shake or shingle, the shake being so shaved with a drawknife that is was thicker at one end than at the other.

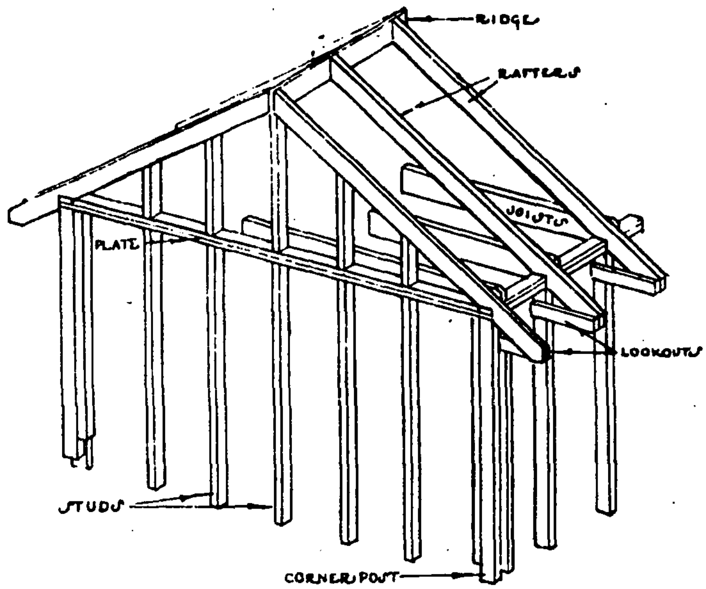
Shingles manufactured today utilizing modern machinery are very uniform in butt thickness and are mass produced to the extent that they are readily available anywhere in the United States.

The species of wood used for shingles are many. Some of the most common are: western red cedar, red wood and cypress. In some sections of the country they are made of eastern white cedar, white pine, southern pine and even sugar pine.

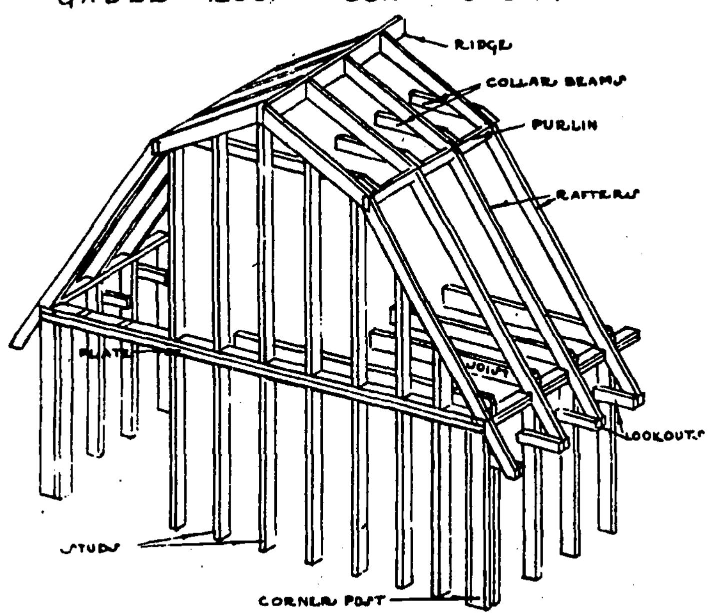
The nail is really the critical factor in the structural stability of the shingle roof. Copper or zinc coated, hot-dipped cut iron nails were used with great success for years. Today, anodized aluminum and galvanized nails are being used with good results. The common wire nail should be avoided. No one would intentionally use a 40 year shingle with a 5 or 10 year nail; but, lack of attention given to the nail used in laying shingles has caused many roof failures. The wire nail rusts and the shingles loosen and fall away long before they wear out by weathering.

Application of shingles: Lay the first course, two ply, allowing for 1¼ to 2 inch projection over crown mold, and 1 inch projection at gables. If shingles are not thoroughly wet, spacing should be 1/8 inch. Do not drive the heads of the nails into the shingles. Break joints not closer than 1¼ inches, side lap. Be sure that breaks do not come directly over each other on any three consecutive courses.

Valleys may be formed as either open or closed valleys. The open valley consists of laying strips of sheet metal in the valley angle to form a channel for water to drain off and then lapping the shingles or other roofing material over the edges of the sheet metal. This is the most commonly used method. In closed valleys, the roofing material entirely covers the sheet metal flashing in the valley and fits together at the valley line.



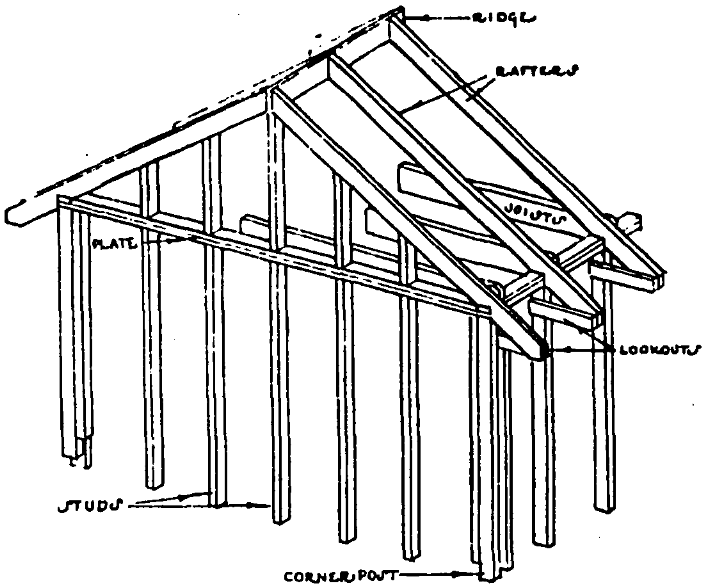
GABLE ROOF CONSTRUCTION



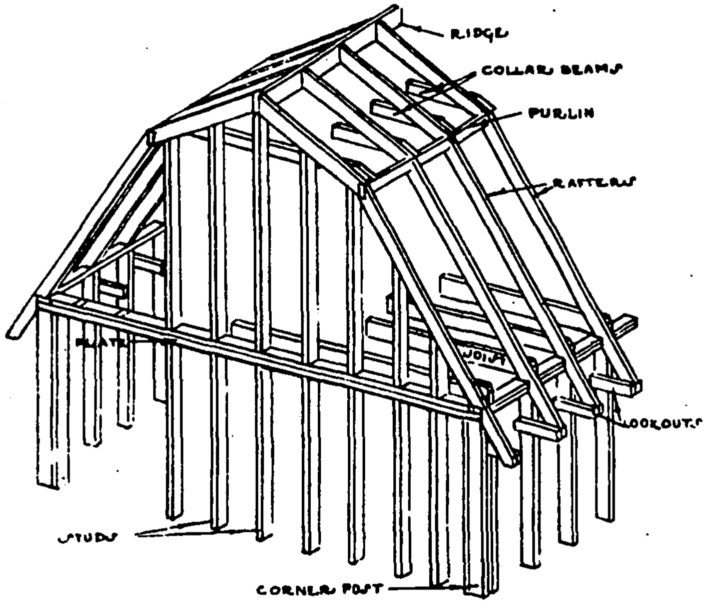
GAMBREL ROOF CONSTRUCTION.

• ROOF • CONSTRUCTION •

FIGURE 10-1a Roof Framing



GABLE ROOF CONSTRUCTION



GAMBREL ROOF CONSTRUCTION.

• ROOF • CONSTRUCTION •

FIGURE 10-1a Roof Framing

Built-Up Roofing. The application of built-up roofing constitutes a major portion of the work done by the roofer, and since many of the applications of such roofs are on large deck areas, much of the processing may be done by mechanical means. However, applying roofing on small deck areas by mechanized means is impractical and is therefore performed by hand.

The quality of any roofing job is controlled somewhat by the materials used for the job, and these materials are usually chosen in the light of what the customer wants or can afford. However, while it is certainly true that no roofer, no matter how skilled, can do a quality roofing job while using inferior or inadequate materials, this is no reason for lessening in any way the quality of workmanship that goes into the job.

Two prime ingredients for a quality roofing job are:

1. Good materials
2. Knowledge and skill of the craft

Owing to the very nature of roofs, it is not practical or possible to prefabricate a roof. Every roof must be fabricated on the roof deck to be covered, and built-up roofs are made by sealing layers of roofing felt together with bitumen adhesive. Each layer of felt is called a "ply".

The type of roof and number of plies to be used on any job may be determined by the roof engineer, architect, specification writer, or the roofing contractor. Many factors influence this decision--the prevailing climate in a given area, the type of deck being covered (whether it is concrete, gypsum, wood, or steel), the pitch of the roof, and building codes. For example, the flatter a roof the more plies required: a deadflat roof usually requires a minimum of 4 plies, and roofing material manufacturers specify 4 plies over concrete and insulation, and prefer 5 plies over wood.

Roofing felts are usually applied "shingle fashion" so as not to buck water, and are either shiplapped or strapped, depending on the pitch of the roof. This applies to 15, 30, 40, or 50 lb. felt, depending on the specifications. Any roof with more than a 1" in 12" pitch will require that the felts be nailed as well as sprinkle-mopped to prevent the sheets from slipping off the deck. Heavier material is either mopped or flopped in place, but the lighter weights can either be rolled or pulled into place. Care must always be taken, however, to avoid any wrinkles in the felt, as these may later become blisters which can cause a roof failure.

Felts are mopped solidly together, but never to the deck. They are attached, instead, by nailing or by sprinkle-mopping and nailing. If nailed only, it must be done in such a manner that every sheet is held by the nails.

Application of a 3-Ply Gravel Roof

The construction of a built-up roof with no cap sheet specified is done as follows:

First Operation: Preparation of roof deck.

Second Operation: Application of insulation.

Third Operation: Application of base or dry sheet.

The base felt application of 3-ply may either be laid up "one and two" or straight 3-shingle fashion. When the pitch of the roof is greater than 1/4" in 12", it is better to lay up a straight 3-shingle fashion to minimize the gravel weight on the exposed portion of the felt. The reason for this is that when laid up with a base sheet (also called a dry or slip sheet), there is a 17-in. strip of exposed felt that must support the gravel; whereas with the same sheets laid up in straight 3-ply, the exposed portion is minimized, thereby reducing the amount of gravel weight that must be supported by nails.

Perforated felt should never be used when laid "one and two" since this is meant to be bedded. A rosin sheet is always used as a slip sheet, which also prevents asphalt from dripping between the roof deck sheathing.

Purpose of a Drysheet

The main reasons for using a drysheet are:

To prevent the normal expansion and contraction of the deck from buckling the finished roof assembly

To prevent the moisture from penetrating insulation materials (providing a saturated felt is used)

To allow the roof deck to breathe, thereby preventing the formation of blisters.

Disadvantages of a Drysheet

Drysheets have disadvantages, and the following are two prime examples:

1. A drysheet may develop wrinkles if exposed to the weather while waiting to be covered with plies. Sprinkle-mopping prevents this condition to some extent, as does water glazing. (Note: sprinkle-mopping is permissible on any deck except 1" x 6" sheathing.)

2. A drysheet, when nailed, has a tendency to tear up and blow off easily. Sprinkle-mopping helps to prevent this to some extent, but the presence of asphalt on the top of the sheet, which is hard to avoid, results in the drysheet sticking to equipment or the workmen's feet, causing holes to be torn in the sheet before the roof assembly is applied.

Application of a Roof Assembly with a Base Sheet and Two Felts

The correct procedure for applying a roof assembly with base sheet and two felts is as follows:

1. Starting at the lowest, or drain, point of the roof, lay a full 36-in. base sheet and proceed up the incline, lapping 2 in. on side laps and 4 in. on end laps.

2. Start the 2-ply at the low point by solid-mopping an 18-in. wide roll of felt, then solid-mopping a 36-in. area and embedding a full roll, leaving 17 in. exposed. (Figure 10-2)

Application of a Straight 3-Ply Roof Assembly

Safety Note: When applying felts in the following manner, care must be taken to prevent hot asphalt from dripping through cracks in the sheathing when 1" x 6" decks are being covered. It is best to keep the mop bucket or cart close to the sheet being mopped to avoid splashing the asphalt on the unprotected deck.

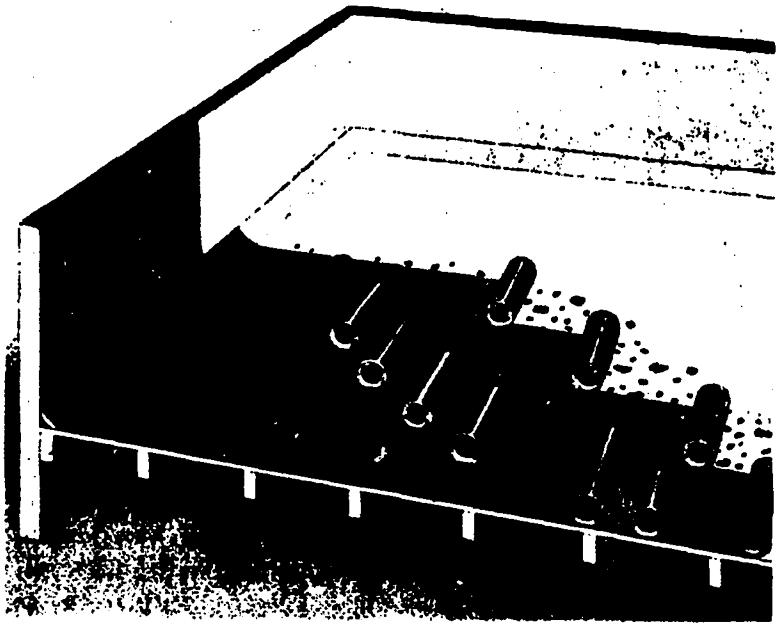


FIGURE 10-2 Roof Assembly with Base Sheet and Two Felts

1. Starting at the lowest, or drain, point of the roof, lay a 1/3 sheet of felt by nailing or sprinkle-mopping (nailing only on 1" x 6" sheathing).

2. Solid mop this 1/3 sheet and embed the remaining 2/3 sheet.

3. Solid mop the 2/3 sheet and embed the full sheet.

4. Proceed up the incline, lapping each sheet 24-2/3 in. leaving 11-1/3 in. exposed (Figure 10-3).

A rule to remember: To find the number of inches of exposure, it is necessary to divide the number of plies into 34 in. Since 2 in. is required for a headlap (which also provides a little margin for error), only 34 in. is left to use from the full 36-in. width. For example, with a 3-ply assembly:

$$\frac{34}{3} = 11\text{-}1/3 \text{ in. exposure}$$

With a 5-ply assembly:

$$\frac{34}{5} = 6\text{-}4/5 \text{ in. exposure}$$

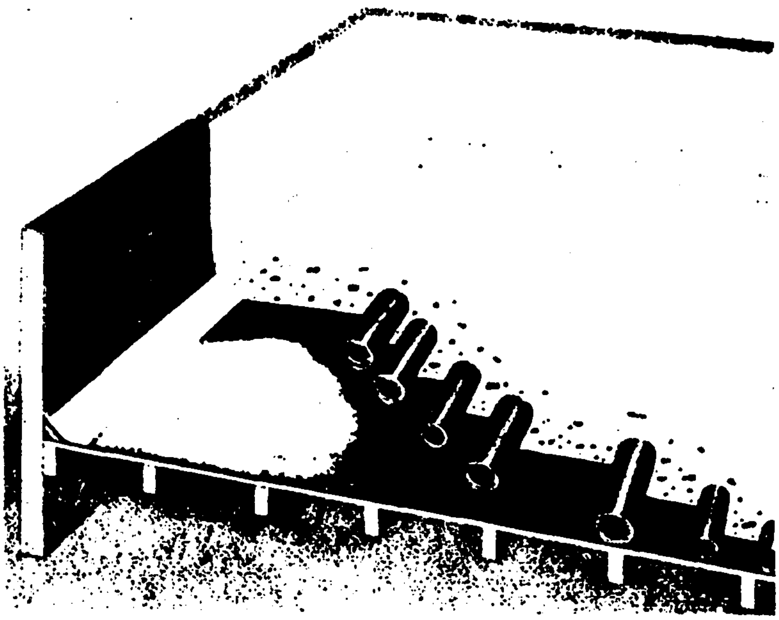


FIGURE 10-3 Straight 3-Ply Roof Assembly

Application of the Gravel Surface

For a quality application of gravel, a minimum of 40 lb. of asphalt per square is usually needed; certain roof and weather conditions may require more. An amount this large must be poured; the steeper the roof, the cooler the asphalt will have to be to keep from running. Around gravel stops and eaves, however, the asphalt must be mopped. All hips and ridges must be double-rocked, which requires two separate applications of asphalt.

Gravel is spread immediately behind the application of hot asphalt to avoid bare spots (called "holidays"). The amount of gravel (or rock) required depends on its size and type. It must be spread evenly and smoothly and devoid of "holidays." It should also be "dolled up" as soon as possible.

It should be noted here that new developments in aggregates for roof surfacing have made possible the use of increasingly larger quantities of material with appreciably less weight, thus providing better coverage and protection without danger of roof structure failure. This is especially important where double-graveling is necessary for a more durable roof. In double-graveling, asphalt is poured over the first layer of aggregate, and a second layer is then applied.

Cleanup

The roofer is responsible for cleaning up all excess material, debris, gravel, and so forth on the roof as well as the grounds and walks in the surrounding area.

Checkup

While in the process of cleaning up, it is good practice to inspect the finished job carefully, especially at pipes, curves, and flashings to make sure that the plastic in these areas has been correctly applied and that there are no breaks. All outlets, overflows, and drains should likewise be inspected to make sure they have been cut open, properly sealed, and are free of any blockage. This kind of careful checkup may prevent a repair call later on or water damage to the roof or building because of a subsequent failure.

Applying a Mineral Surface Capsheet

Capsheet is frequently used when the roof is steeper than 3" in 12", as gravel will generally not hold on such a slope.

The application of base felts for a capsheet installation is identical to that for a gravel surface roof. The following is a summary of materials used on a typical capsheet job.

Materials	Weight per Square
2 layers of No. 15 asphalt felt (perforated felts may be used)	30 lb.
Roof asphalt	50 lb.
1 layer of 90-lb. mineral capsheet	90 lb.
Approximate total weight	170 lb.

The mineral surface capsheet on a roof is the exposed sheet. A very important step in laying mineral surface roofing is to allow the rolls of capsheet to stretch, since they are rolled and wrapped tightly at the factory. If they are not stretched prior to laying, they will stretch afterwards, causing buckles and bows. Stretching can be accomplished by stock-piling 36-ft. lengths of capsheet on the high point of the roof, keeping the granule side down and the roll ends even. They may then be cut into the desired lengths and brought down into place ready for flopping. Stretching by this method takes only a few minutes, especially in hot weather.

There are many different ways to lay out a capsheet roof, but it should always be done neatly with all end laps staggered by at least 2 ft. and header sheets installed around all edges. Capsheet should always be laid so that none of the sheets will buck water.

One method of application is to "stairstep', or "stepback", as follows:

1. Lay the sheets in sequence, starting with an 18-ft. sheet, followed by a 14-ft., a 12-ft., and so on.

2. Bypass pipes 4 in. and bring the next sheet to the pipe, covering the cut.

3. Place all pipe jacks, vents, and the like as the material is being laid.

4. If the roof has a pitch, nail the selvage edge according to the specifications for the job.

5. If the pitch of the roof is steep, the capsheet may be laid vertically with the top edge nailed 6 to 8 inches on center about 3 inches down from the top edge.

If capsheets used are no longer than 18 ft., they will be easier to handle and a better job can be done. Some roofers use a "slop" sheet to do a neater job--this is a piece of capsheet cut straight off the end of the roll and laid at the endlap to enable the mopman to maintain a straight, neat edge. Capsheets should never be nailed solidly to an old roof deck; they should always be mopped either to a newly-applied or a nailed-down base sheet.

For capsheet jobs requiring an especially neat appearance, matching granules may be sprinkled on any exposed asphalt as soon as the capsheet is flopped and while the excess asphalt is still hot enough to allow adhesion. This process is also necessary when the roof is to receive a protective coating, as this provides a surface for the coating to cling to.

Glazing

The purpose of glazing is to prevent the curling of seams of all exposed felt when it is necessary to leave them overnight, over weekends, or during work stoppages.

Most specifications of roofing jobs indicate a standard procedure such as: "Cover exposed felts with gravel or capsheet at the close of the day, or glaze the roof." There is however, one exception: If the felts are to be graveled or otherwise covered the following day, it is best to leave them unglazed, for it is difficult to walk on a newly-glazed roof on a hot day. The time of year and prevailing weather conditions, therefore, have a bearing on what is done in this regard. If overnight dampness is to be expected, or if the unfinished roof is to be left more than one day, it is probably best to glaze it. This decision becomes even more difficult to make if low-melt asphalt is used, because it is difficult to walk upon or push wheeled equipment over it without tearing up the felts.

The procedure for glazing is as follows:

1. Spray a fine mist of water over the exposed felt to be glazed.

2. Mop with hot asphalt. (The water allows the mop to slide easily over the surface, leaving behind a very thin coating of asphalt.)

3. If for some reason a regular water spray cannot be used, a bucket of water and a burlap sack can be used to sprinkle water over the felt. Even the hand can be used to accomplish this.

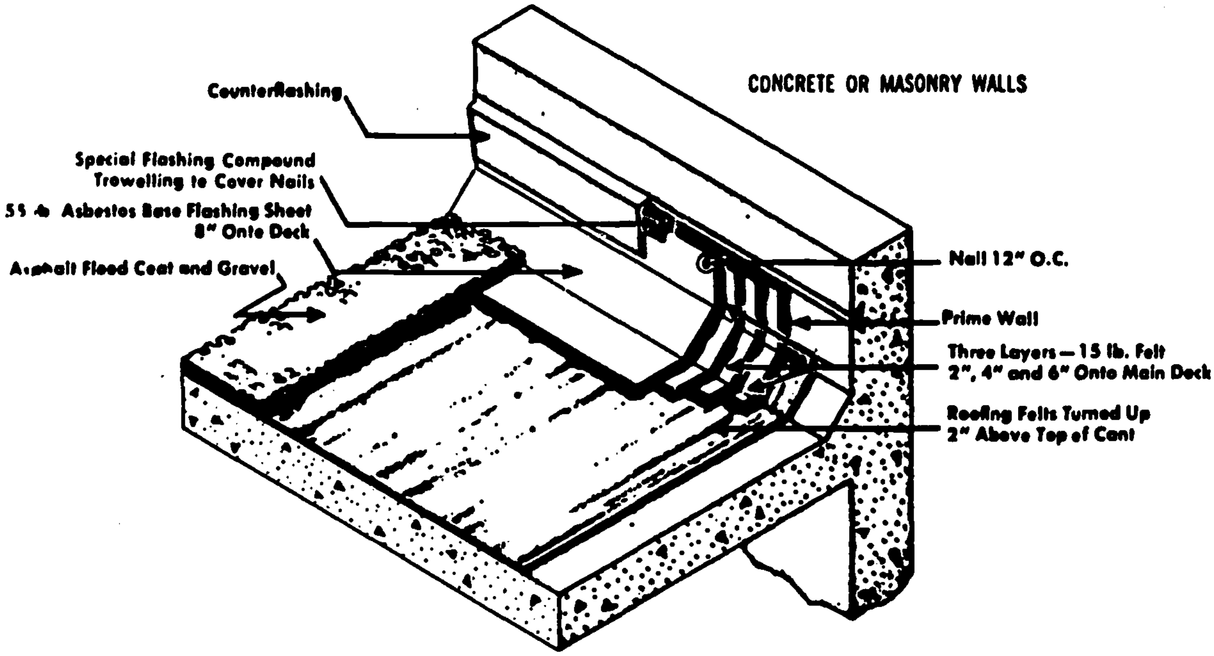
Safety Note: When sprinkling by hand, use a clean, galvanized pail for the water. A pail previously used for hot asphalt will make the water take on the appearance of "hot", and it has been known that a roofer, in the process of sprinkling, picked up a bucket of hot asphalt by mistake, suffering severe burns as a result.

Topcoating

In those areas of the country where the weather is not severe on roof surfaces, only topcoating is done. This consists of about a 40-lb. solid mopping. In normally cold country, the resultant "black" roof absorbs heat from the sun and actually helps warm the building. It also acts to melt snow at a rapid rate, since heat from the building escapes through the roof. The initial cost of the roofing is reduced because no expensive capsheet is applied.

Reflective coatings of aluminum are sometimes used on roofs in hot climates. It is especially important that perfect coverage be achieved in these cases without any "holidays". Maintenance cost is reduced and roof life expanded by periodic recoatings.

Topcoating should be done over sheets of 40 lb. and heavier, except lightweight asbestos sheets and glass, as these form a durable base. These sheets will actually last longer without recoating, whereas 15-lb. and 30-lb. regular felts will deteriorate rapidly after the coating dissipates.



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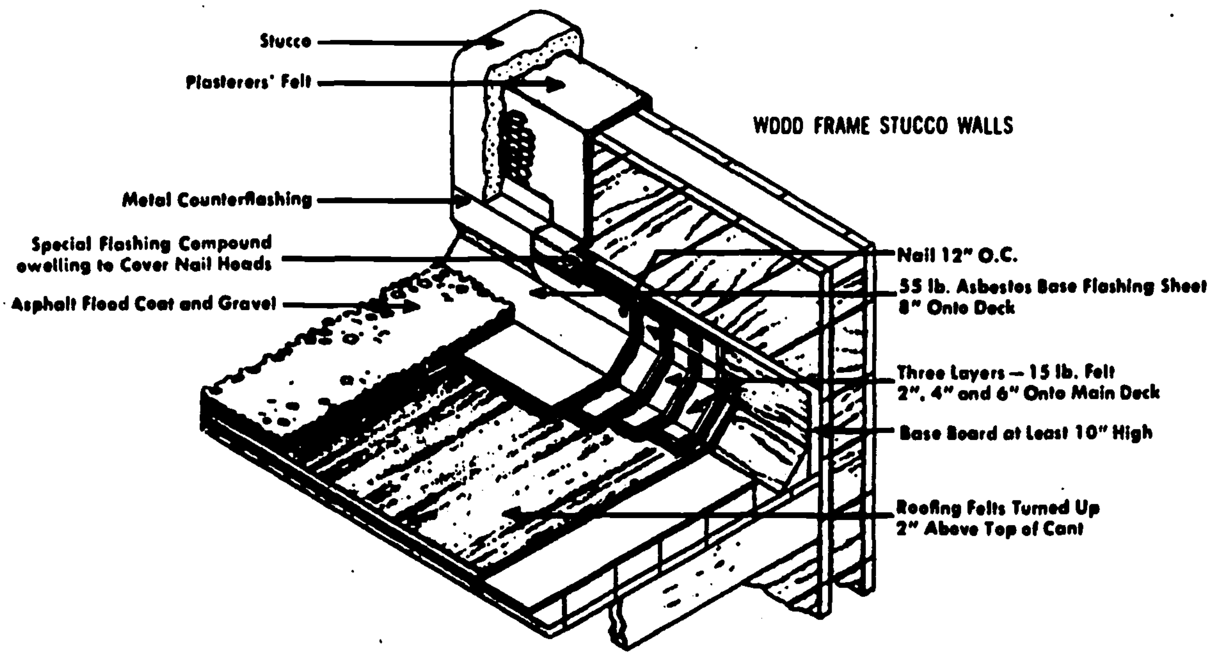

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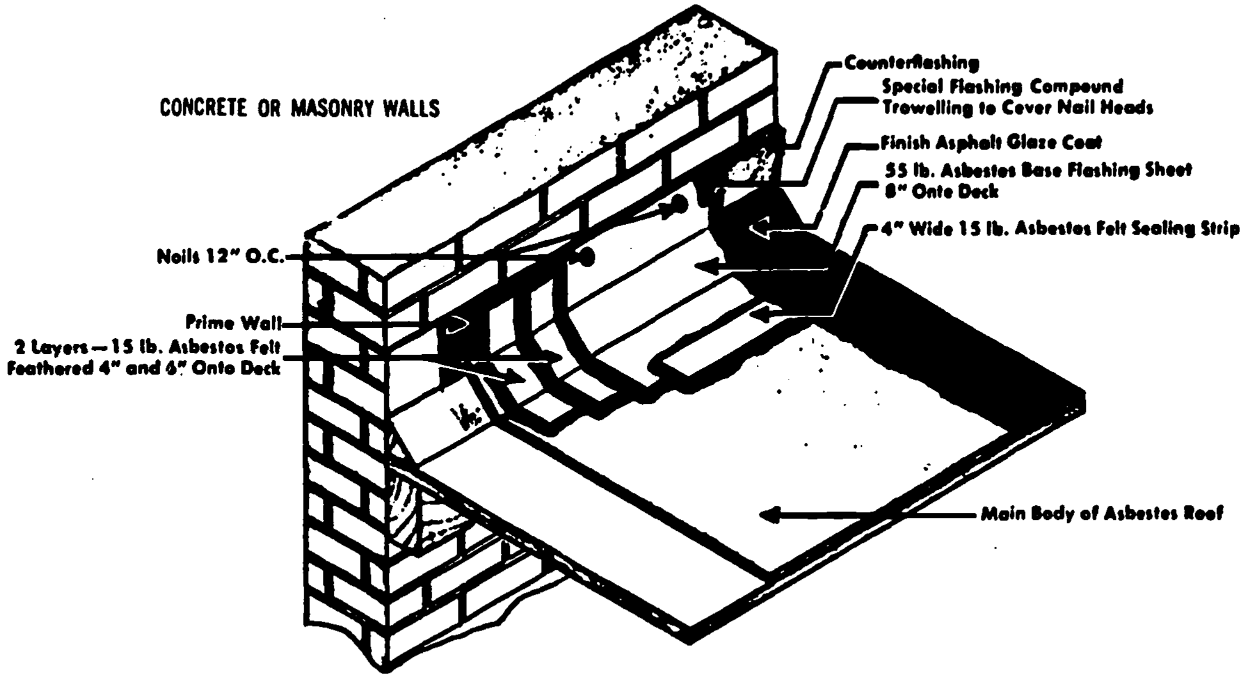
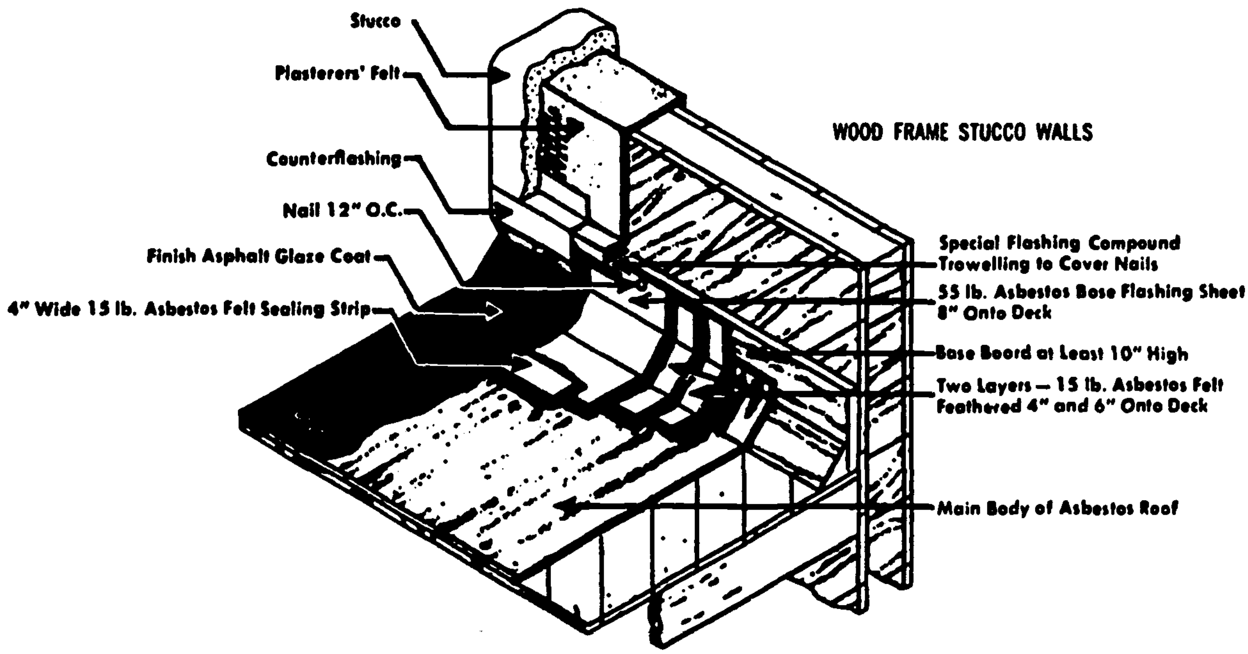
Flashing on gravel roofs



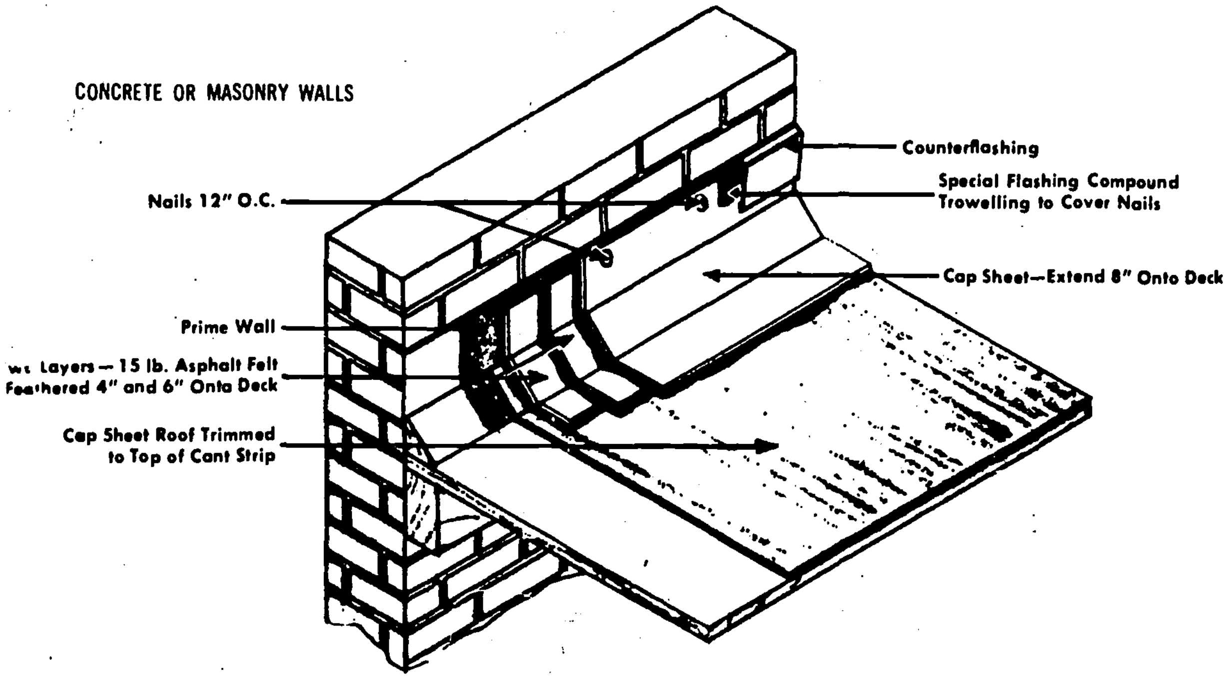
DETAIL B'-B'



DETAIL B'-B'

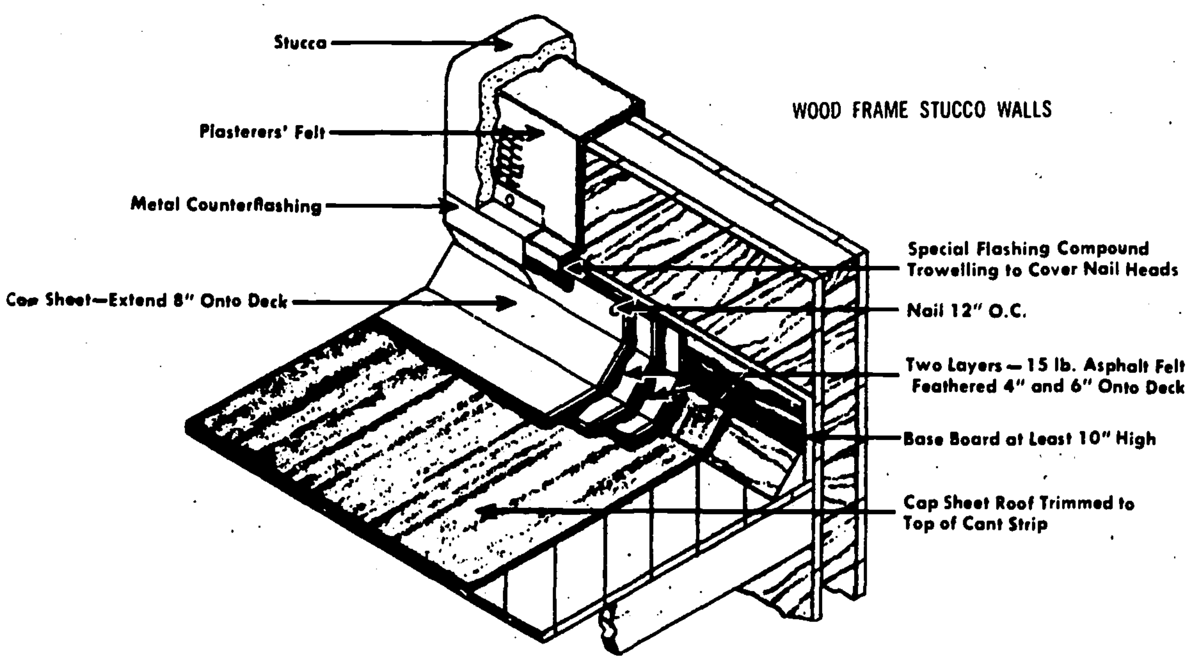
Flashing fc. smooth surface asbestos roofs

CONCRETE OR MASONRY WALLS



DETAIL C'-C'

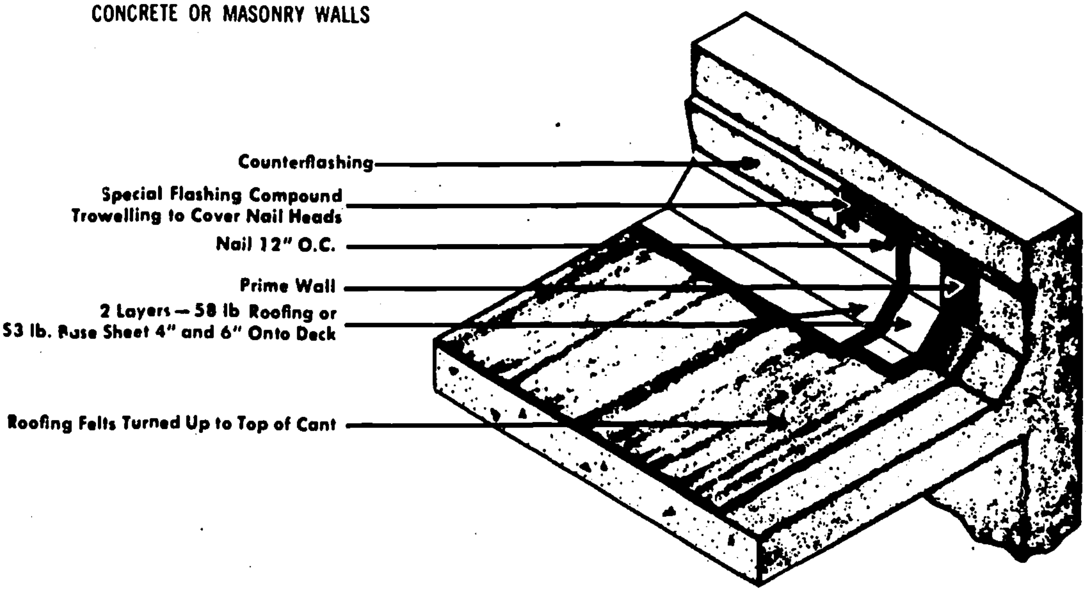
WOOD FRAME STUCCO WALLS



DETAIL C²-C²

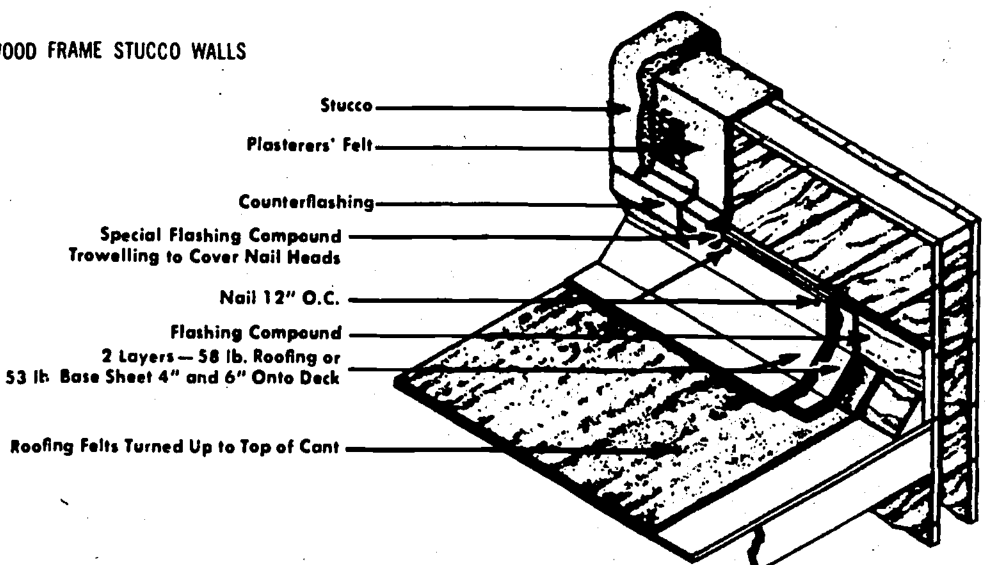
Flashing for capsheet, slate, mineral, and alumi-shield roofs

CONCRETE OR MASONRY WALLS



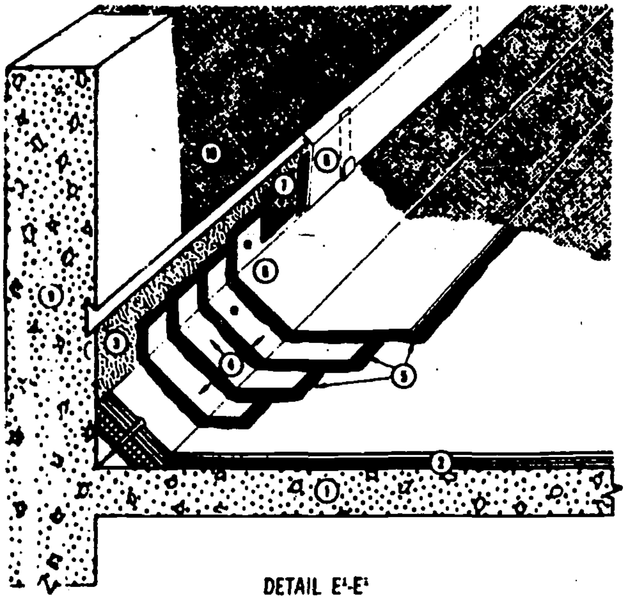
DETAIL D'-D'

WOOD FRAME STUCCO WALLS



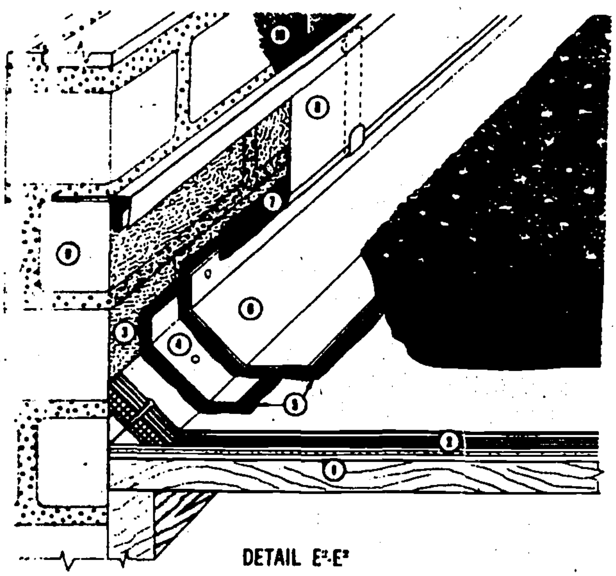
DETAIL D²-D²

Flashing for use with cold process assemblies



DETAIL E¹-E¹

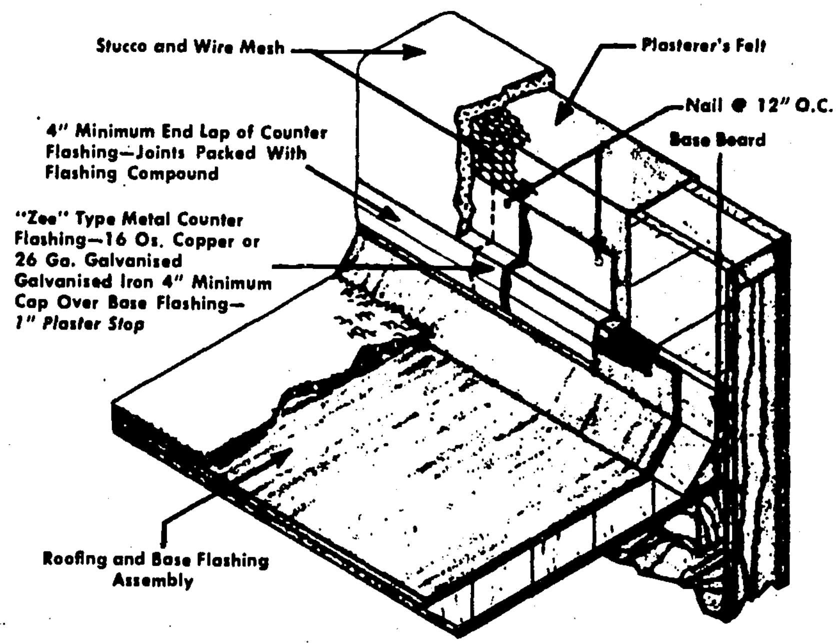
1. Concrete deck
2. Built-up roofing
3. Asphalt primer
4. No. 15 asphalt felt
5. Asphalt moppings
6. Mineral surfaced capsheet
7. Three-course plastic flashing
8. Metal counterflashing
9. Masonry wall
10. Parapet wall coating



DETAIL E²-E²

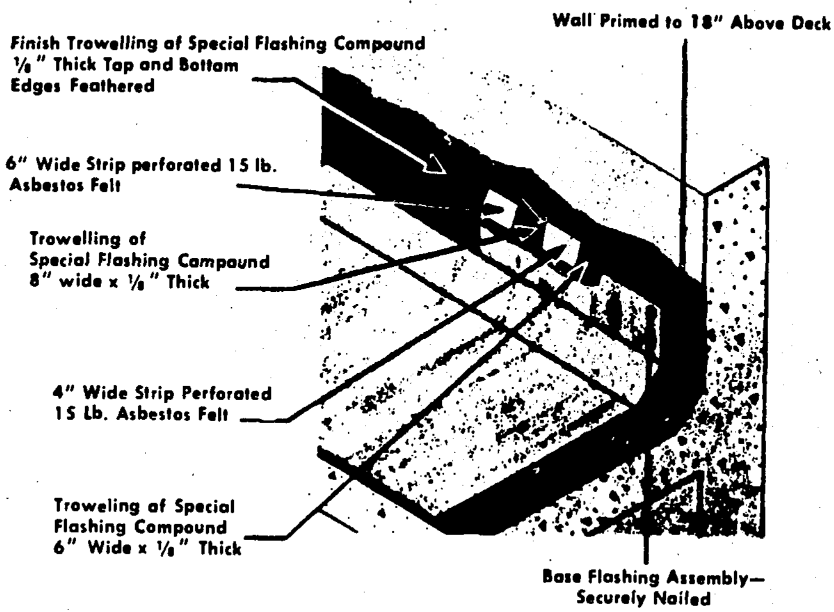
1. Wood deck
2. Built-up roofing
3. Asphalt primer
4. No. 15 asphalt felt
5. Asphalt mopping
6. Mineral surfaced capsheet
7. Flashing compound
8. Metal counterflashing
9. Masonry block wall
10. Parapet wall coating

Metal counterflashing on concrete or stucco walls



DETAIL F-F

Metal counterflashing and stucco stop for wood frame and stucco walls

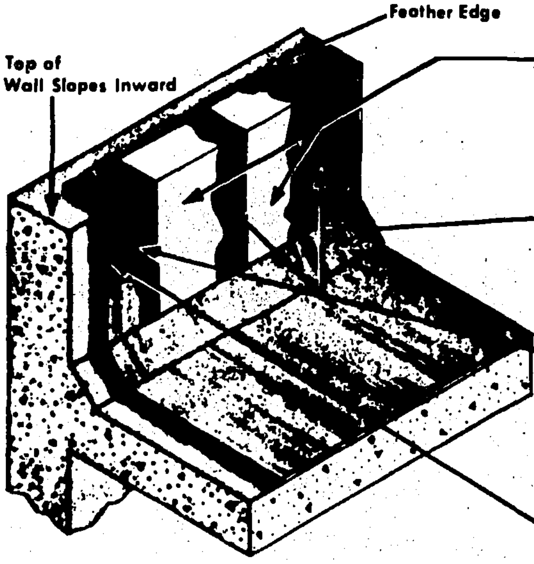


DETAIL G-G

Five-course plastic flashing for concrete walls more than 18 inches high

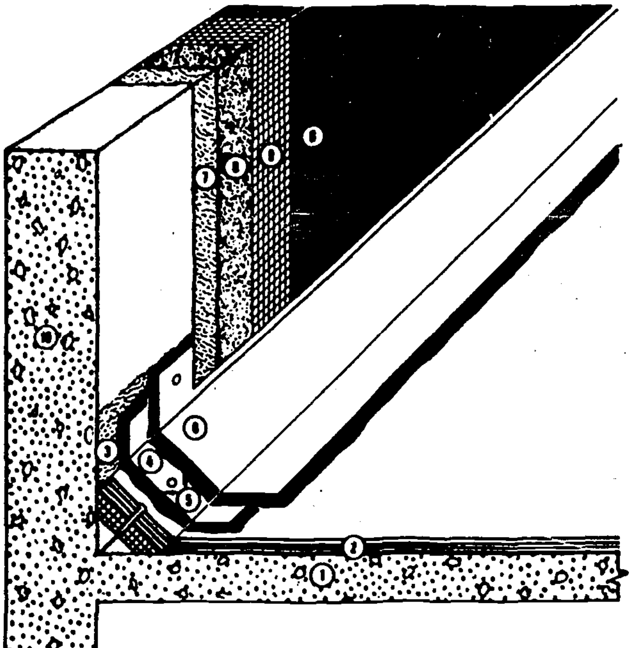
DETAIL H-H

Three-course plastic flashing for concrete walls more than 18 inches high



DETAIL J-J

Five-course plastic cap flashing for parapet walls less than 18 inches high

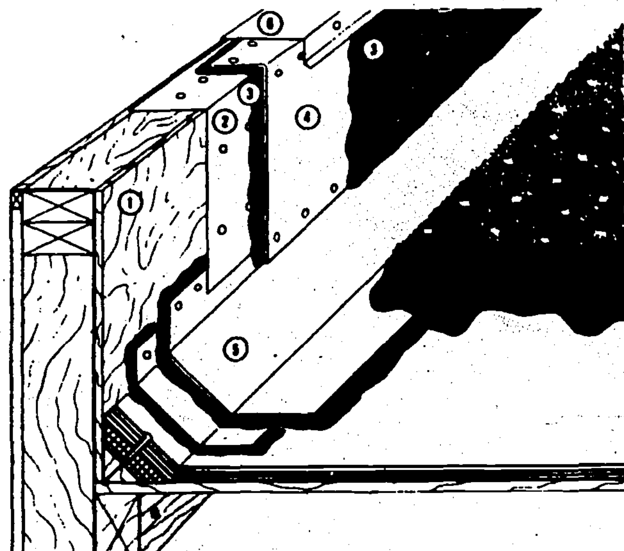


DETAIL K-K

1. Concrete deck
2. Built-up roofing
3. Asphalt primer
4. No. 15 asphalt felt
5. Asphalt moppings
6. Mineral surfaced capsheet
7. Emulsion primer
8. Asphalt emulsion
9. Yellow jacket glass fabric
10. Masonry wall

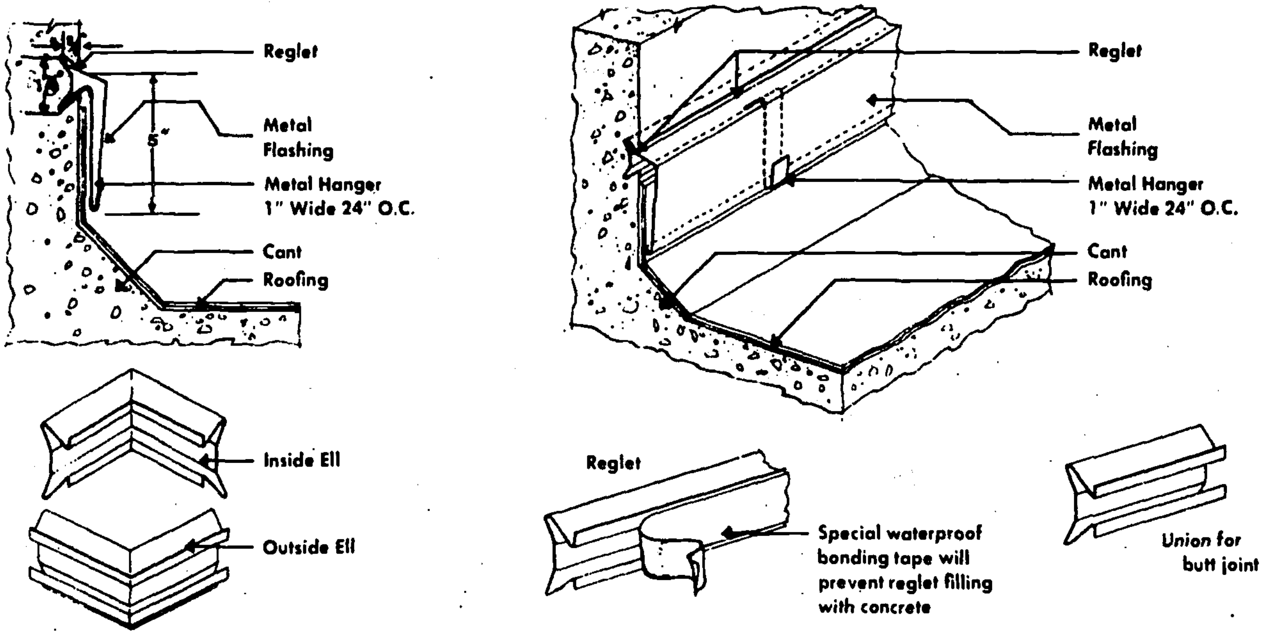
Flashing on a masonry parapet wall

1. Frame parapet wall
2. No. 15 asphalt felt
3. Asphalt mopping
4. 45-lb. asbestos sheet
5. Base flashing
6. Standing seam metal coping

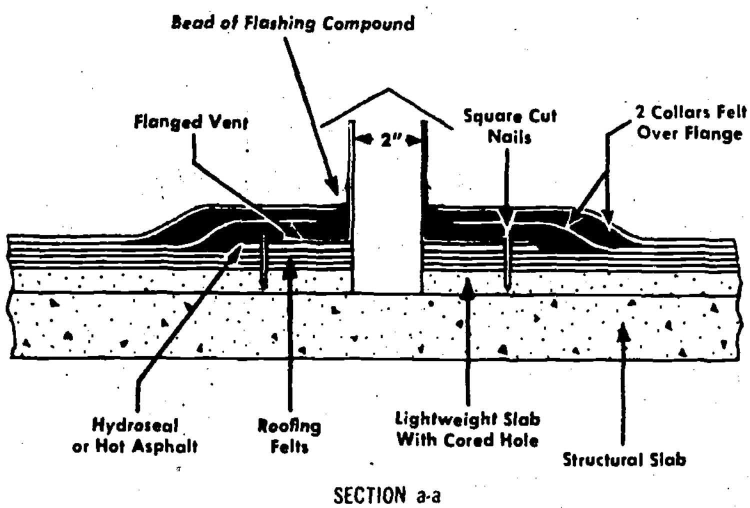


DETAIL L-L

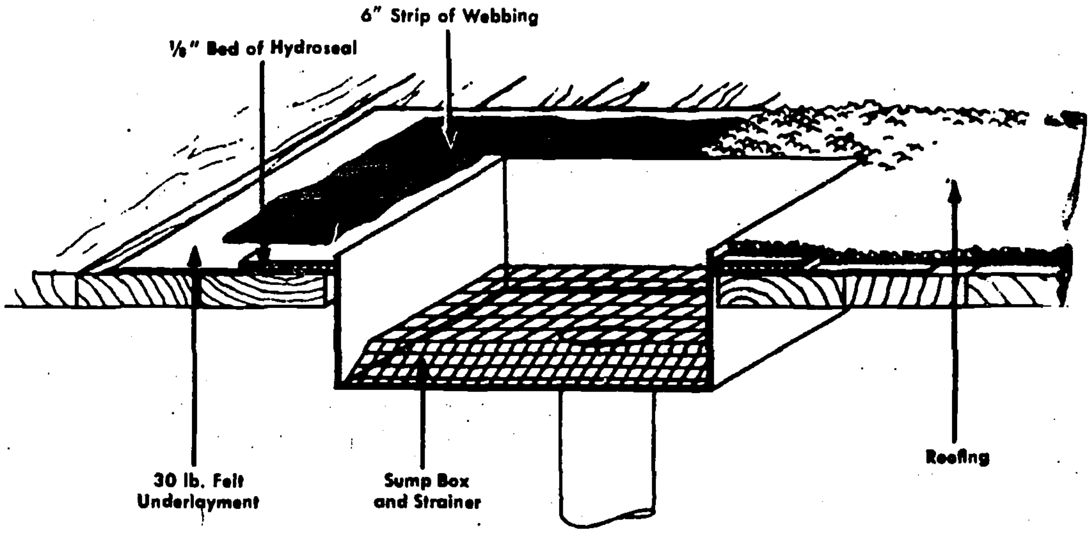
Flashing on a wooden parapet wall



Removable type of wall counterflashing

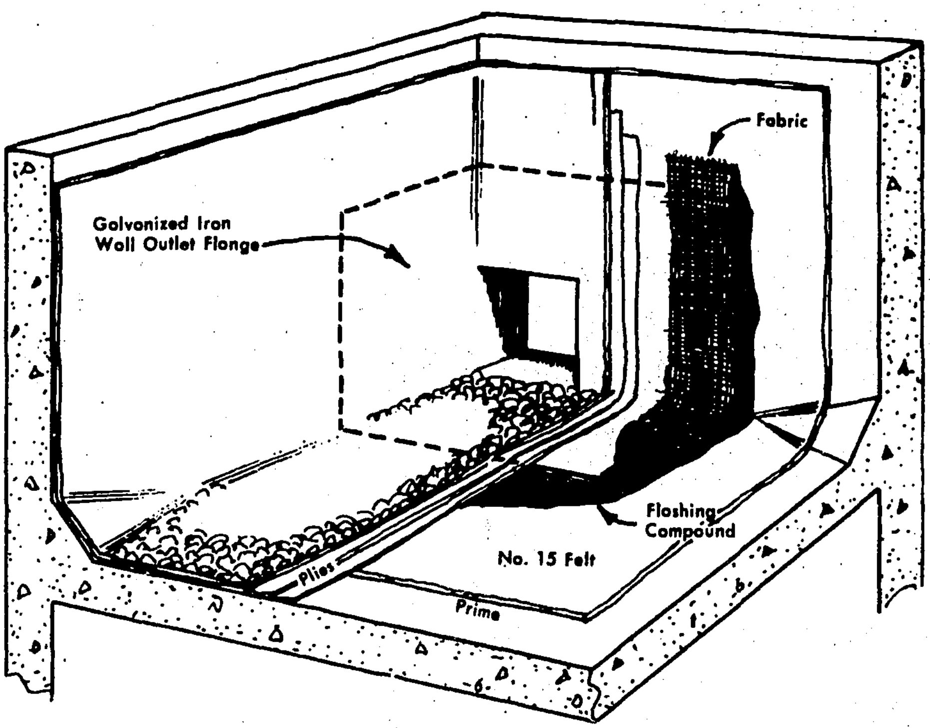


Typical pressure release vent



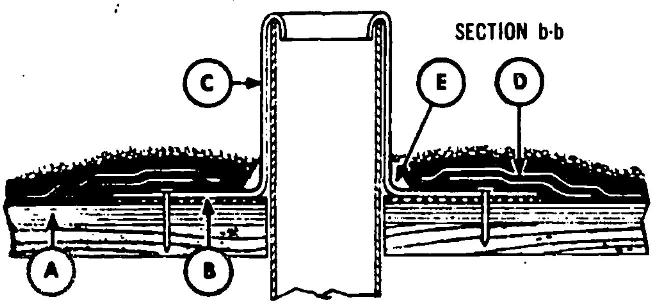
DETAIL M-M

Typical sump drain installation



DETAIL N-N

Typical installation of overflow drain

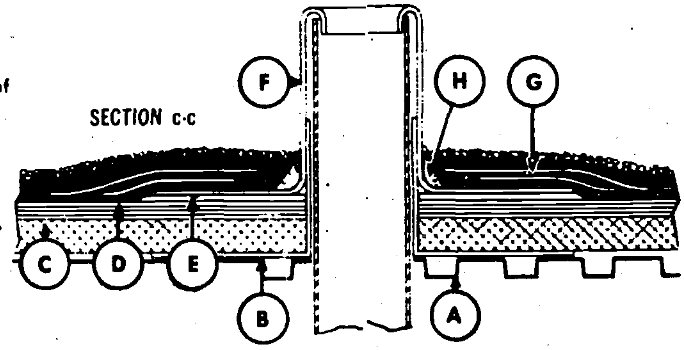


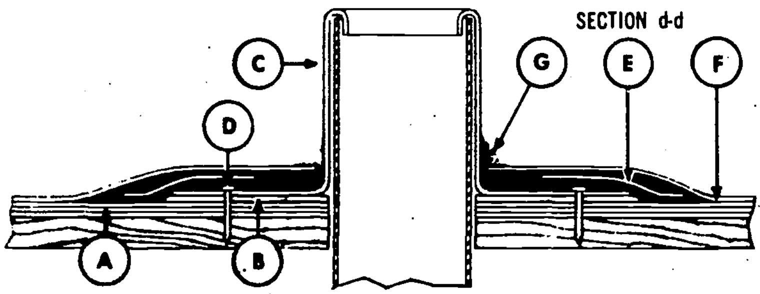
A. Roofing felts
B. Flashing compound (⅛ in. thick)
C. Lead vent pipe flashing in bed of flashing compound, turned down inside pipe
D. Two layers of felt set in asphalt over flange of lead vent pipe flashing
E. Bead of flashing compound encircling flashing

GRAVEL-SURFACED ROOF, SINGLE SLEEVE

A Steel deck
B Inner bottom sleeve extending at least 2 in. above final roof level
Insulation
D Roofing felts
E. Flashing compound (⅛ in. thick)
F Lead vent pipe top flashing
G. Two layers of felt set in asphalt
H Bead of flashing compound

GRAVEL SURFACED ROOF, DOUBLE SLEEVE



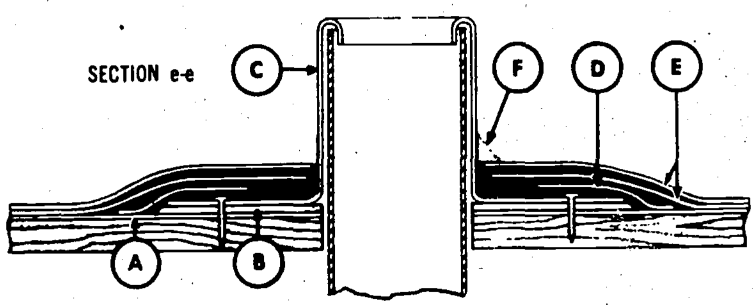


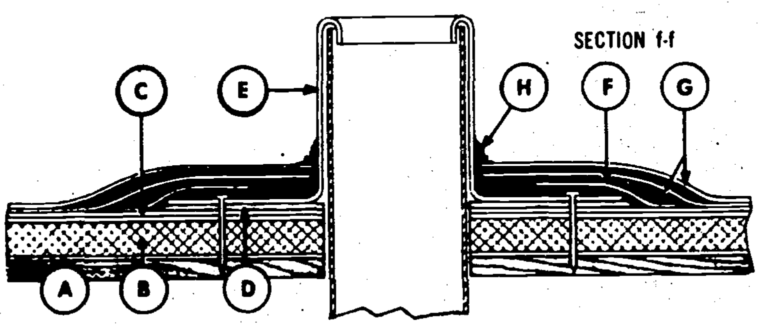
A. Roofing felts
B. Flashing compound (⅛ in. thick)
C. Lead vent pipe flashing
D. Nails
E. 6-in. strip of webbing
F. Capsheet
G. Bead of flashing compound

CAPSHEET ROOFS

A. Base sheet
B. Flashing compound (⅛ in. thick)
C. Lead vent pipe flashing
D. 6-in. strip of webbing
E. Finishing felts for smooth surface roofing
F. Bead of flashing compound

SMOOTH-SURFACED ROOF WITH BASE SHEET



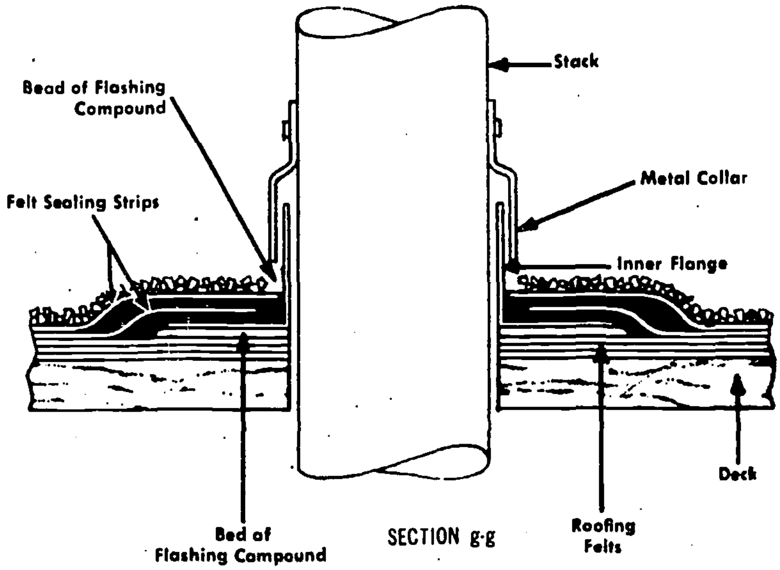


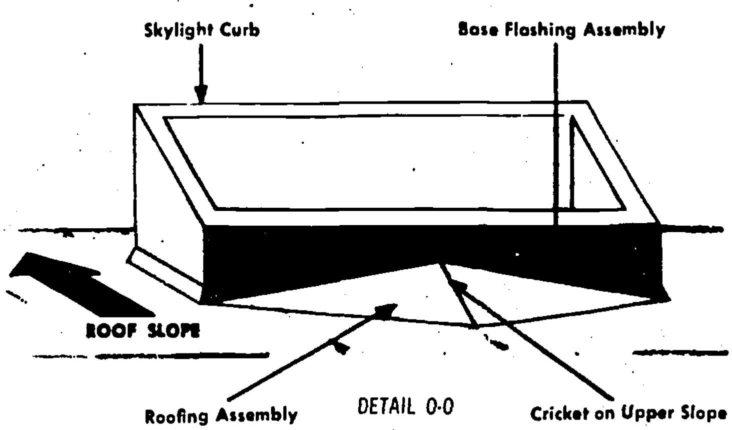
A. Vapor barrier
B. Insulation
C. Bottom two layers of 15-lb. asbestos felt
D. Flashing compound (⅛ in. thick)
E. Lead vent pipe flashing
F. 6-in. strip of webbing
G. Top two layers of asbestos felt
H. Bead of flashing compound

ASBESTOS FELTS OVER INSULATION

Lead sleeve installations

Collars for large stacks and flagpoles

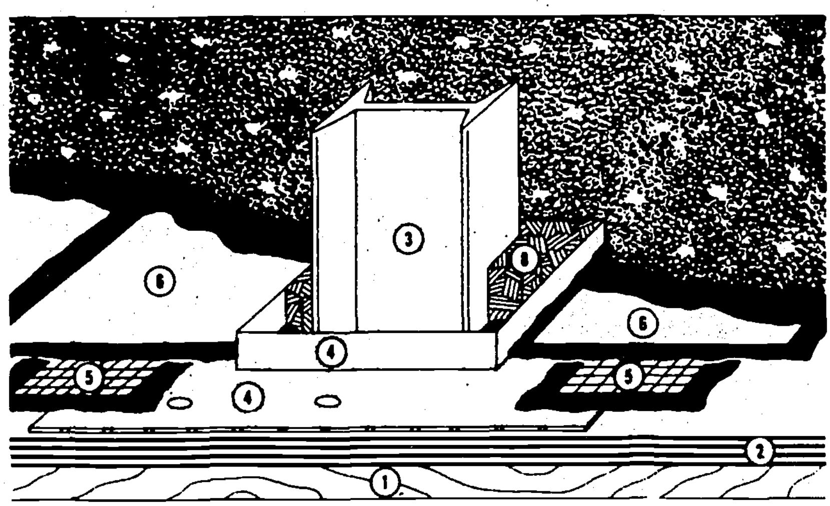




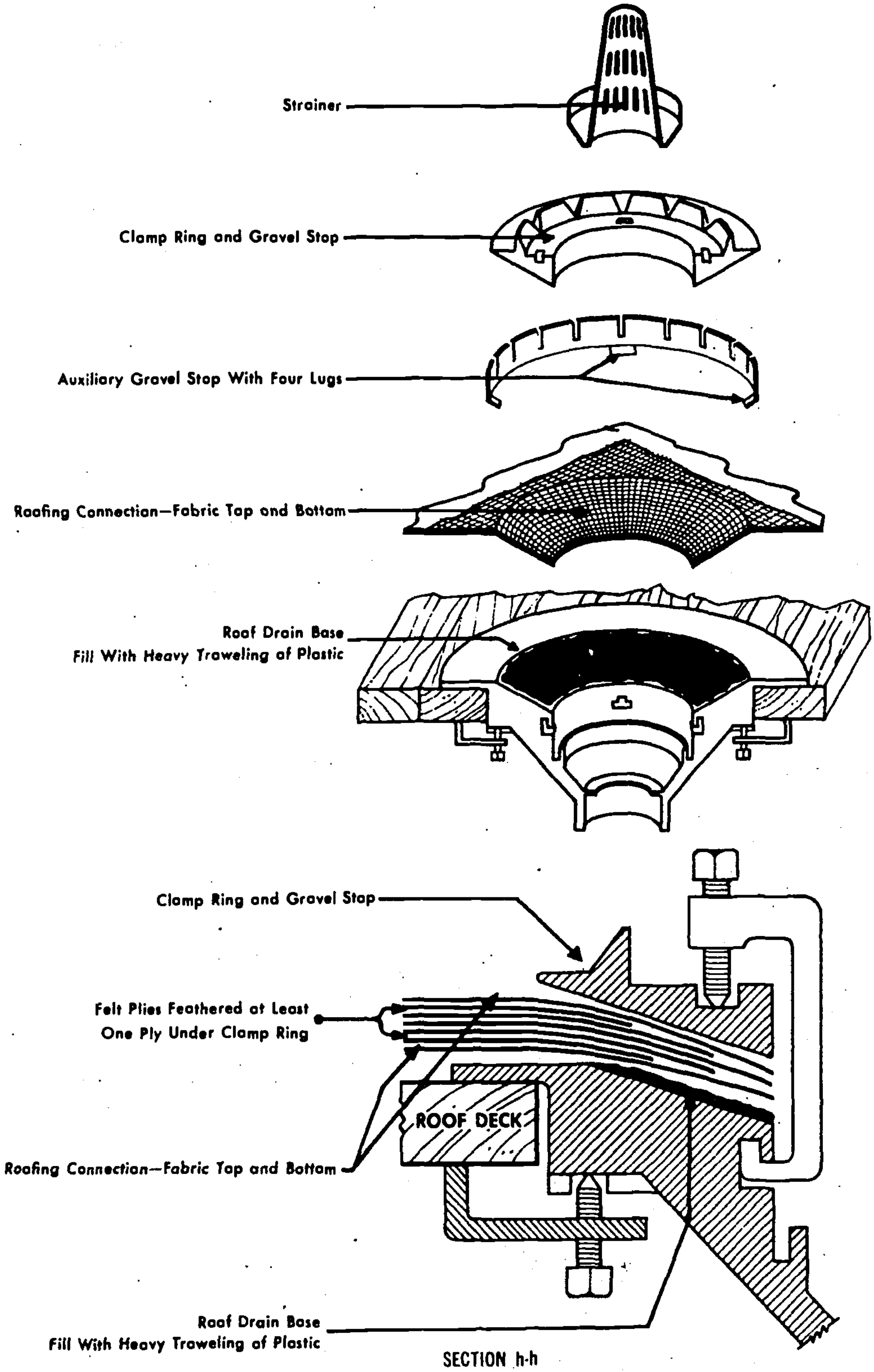
Large ventilators, skylights, and similar structures

1. Wood roof deck
2. Built-up roofing
3. Metal projection
4. Metal pan collar flashing
5. Yellow jacket glass fabric (6" wide)
6. No. 15 asphalt felt (12" wide)
7. Asphalt mopping
8. Flashing compound

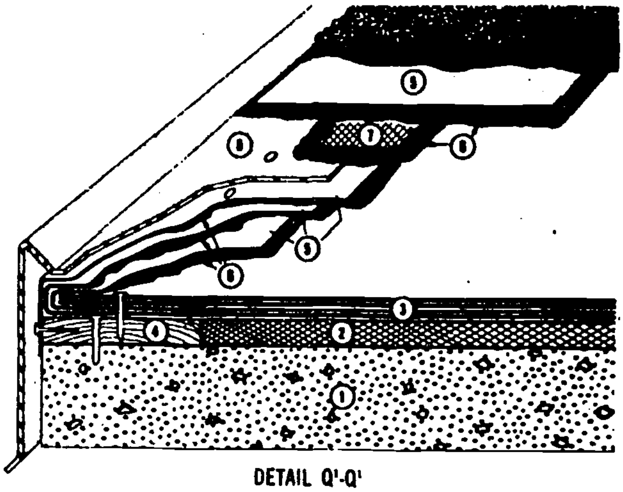
DETAIL P-P



Metal pan collar flashing

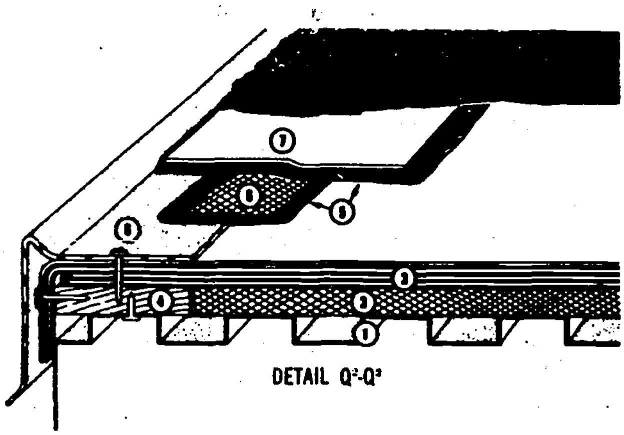


Drain and clamp rings



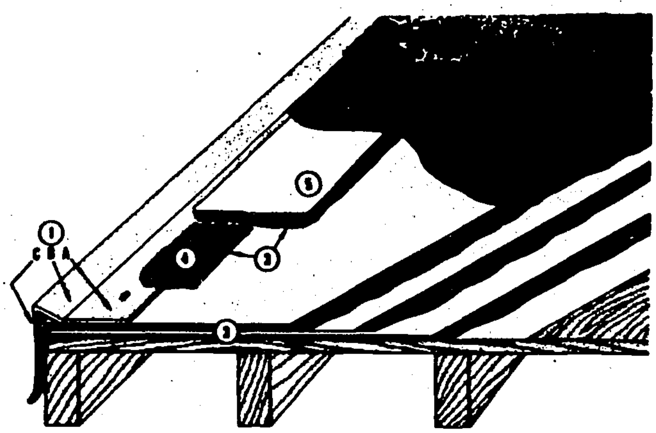
DETAIL Q^1-Q^1

1. Concrete deck
2. Insulation
3. Built-up roofing
4. Wood nailer
5. No. 15 asphalt enveloping felts
6. Asphalt mopping
7. Yellow jacket glass fabric
8. Gravel stop



DETAIL Q^2-Q^2

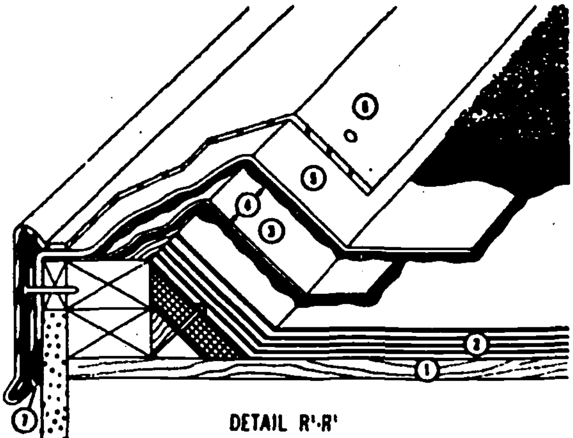
1. Steel deck
2. Insulation
3. Built-up roofing
4. Wood nailer
5. Asphalt mopping
6. Yellow jacket glass fabric (6" wide)
7. No. 15 asphalt felt (12" wide)
8. Gravel stop



DETAIL Q^3-Q^3

1. Gravel stop
   a. Roof flange—4" to 5½"
   b. Rise—¾" max.
   c. Fascia—3½" max. (24 ga.)
2. Roofing felts
3. Asphalt mopping
4. Yellow jacket glass fabric (6" wide)
5. No. 15 asphalt felt (12" wide)

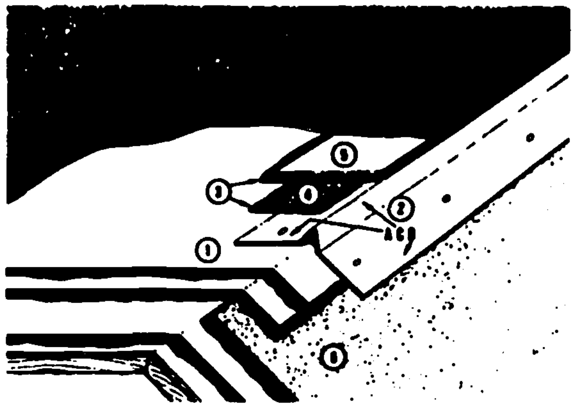
Gravel stop details



DETAIL R'-R'

1. Wood deck
2. Built-up roofing
3. No. 15 asphalt felt
4. Asphalt mopping
5. Mineral surfaced capsheet
6. Combination metal coping and edging
7. Metal clip
8. Wall

Low parapet wall flashing

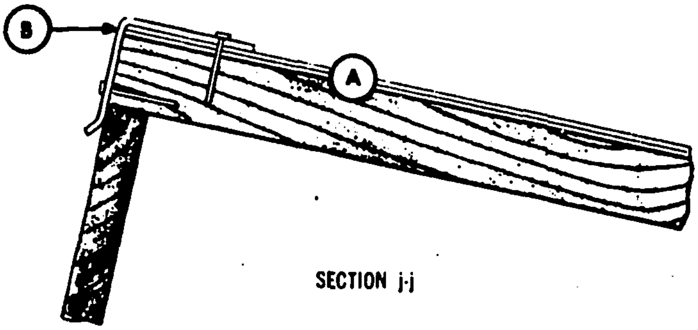


DETAIL R'-R'

1. Built-up roofing
2. Flat-to-steep flashing
   a. 4-in. flange
   b. 6-in. flange
   c. ¾-in. rise (max.)
3. Asphalt mopping
4. Yellow jacket glass fabric (6" wide)
5. No. 15 asphalt felt (12" wide)
6. Built-up roofing or asphalt shingles

Flat-to-steep flashing

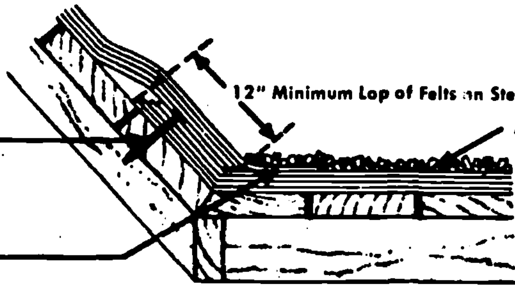
A. Built-up capsheet roof
B. Galvanized metal angle, nailed every 6 in.



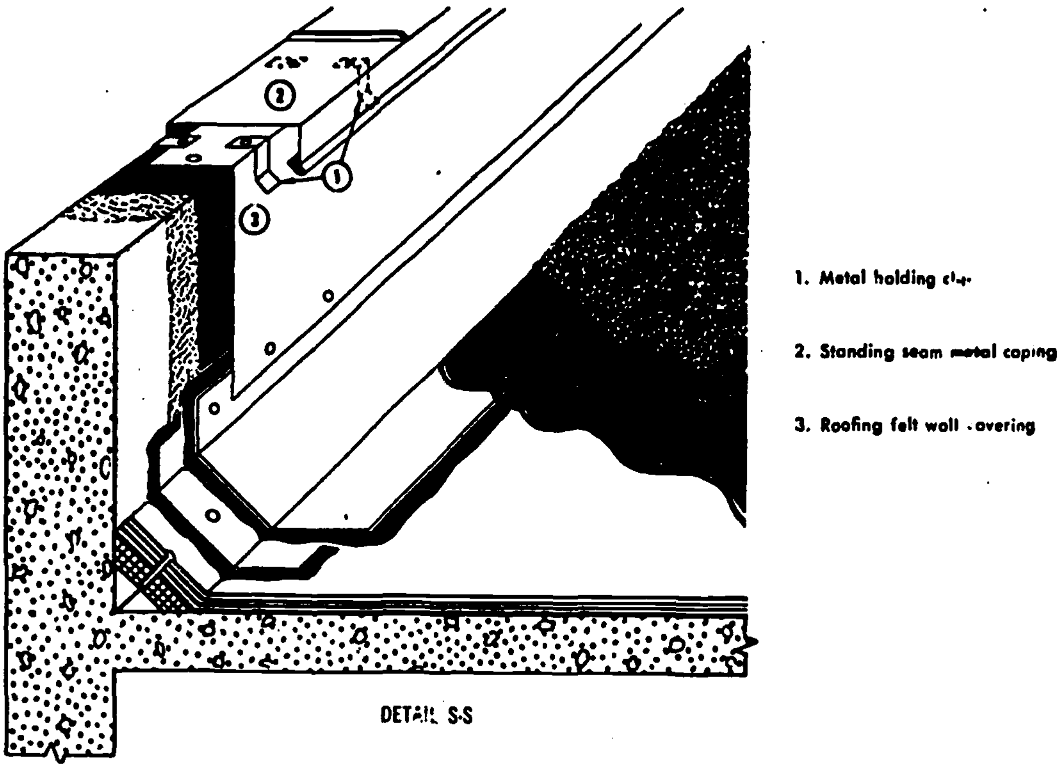
SECTION j-j

Metal ridge cap

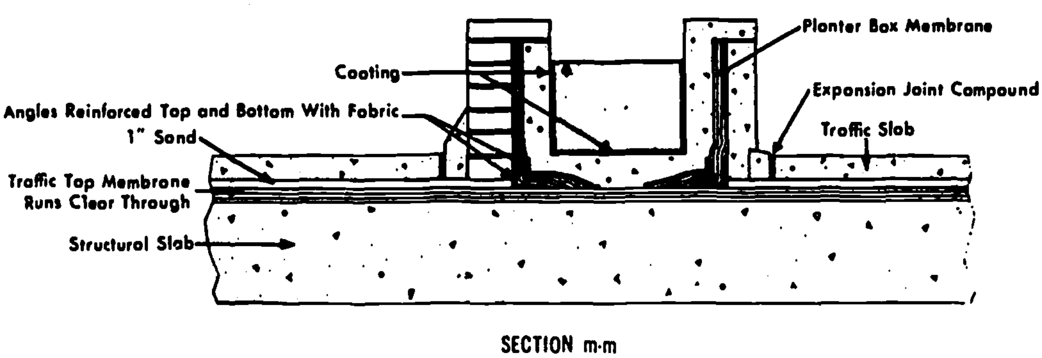
SECTION k-k



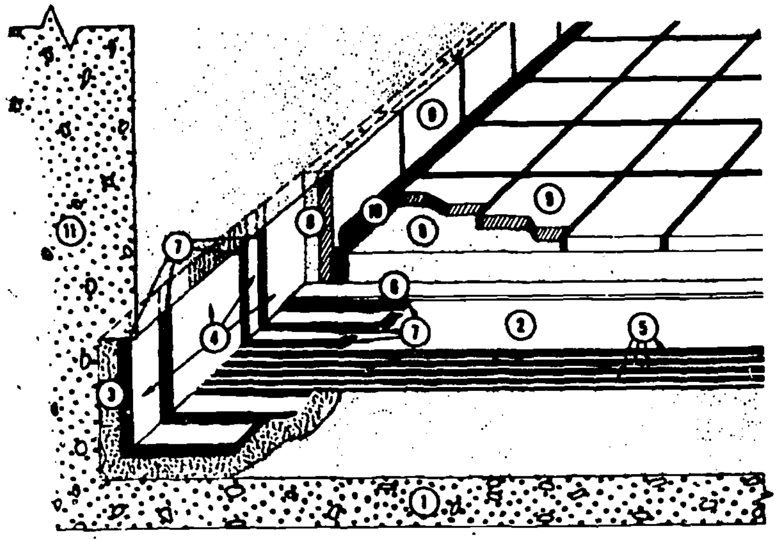
Steep-to-flat roof transition



Expansion joint metal coping



Planter box on traffic top deck

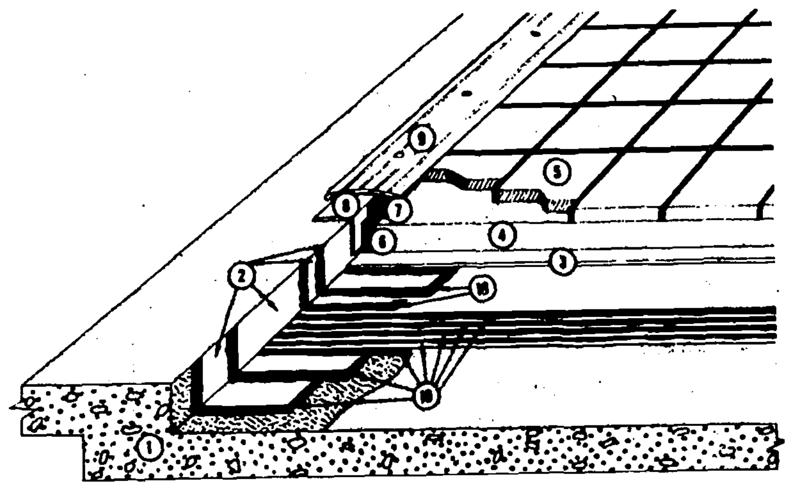


1. Concrete deck
2. Built-up membrane assembly
3. Asphalt primer
4. Reinforcing strips
5. Asphalt mopping
6. Super floxine protection sheet
7. Flashing compound
8. Mortar setting bed
9. Promenade tile
10. Expansion joint sealer
11. Masonry parapet wall

DETAIL T¹-T¹

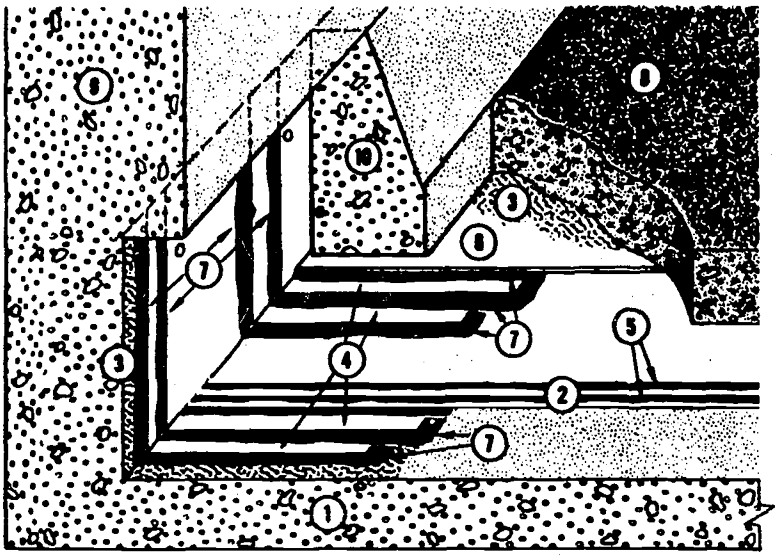
Wall flashing for promenade tile topping

1. Base slab and curb
2. Reinforcing strips
3. Membrane
4. Grout fill
5. Promenade tile
6. Filler strip
7. Joint sealer
8. Metal counterflashing
9. Threshold
10. Flashing compound



DETAIL T²-T²

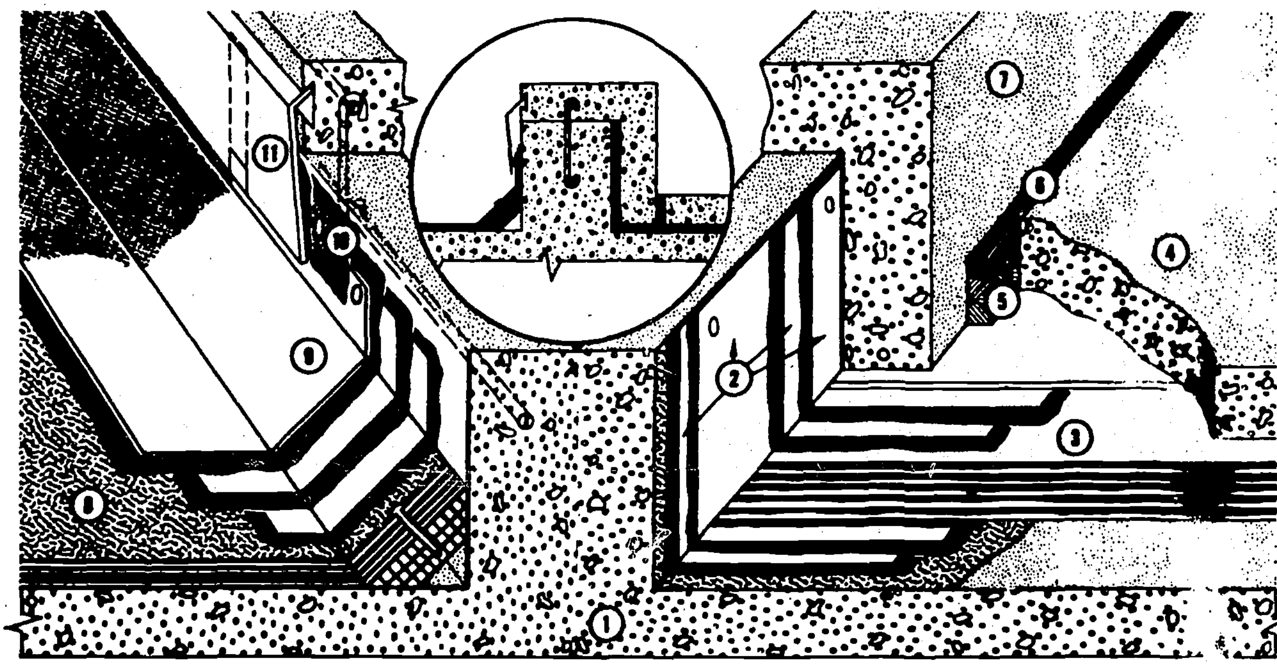
Threshold flashing for promenade tile topping



1. Concrete deck
2. Built-up membrane assembly
3. Asphalt primer
4. Reinforcing strips
5. Asphalt mopping
6. Mineral surfaced capsheet
7. Flashing compound
8. Asphaltic concrete topping
9. Masonry wall
10. Concrete curb

DETAIL U¹-U¹

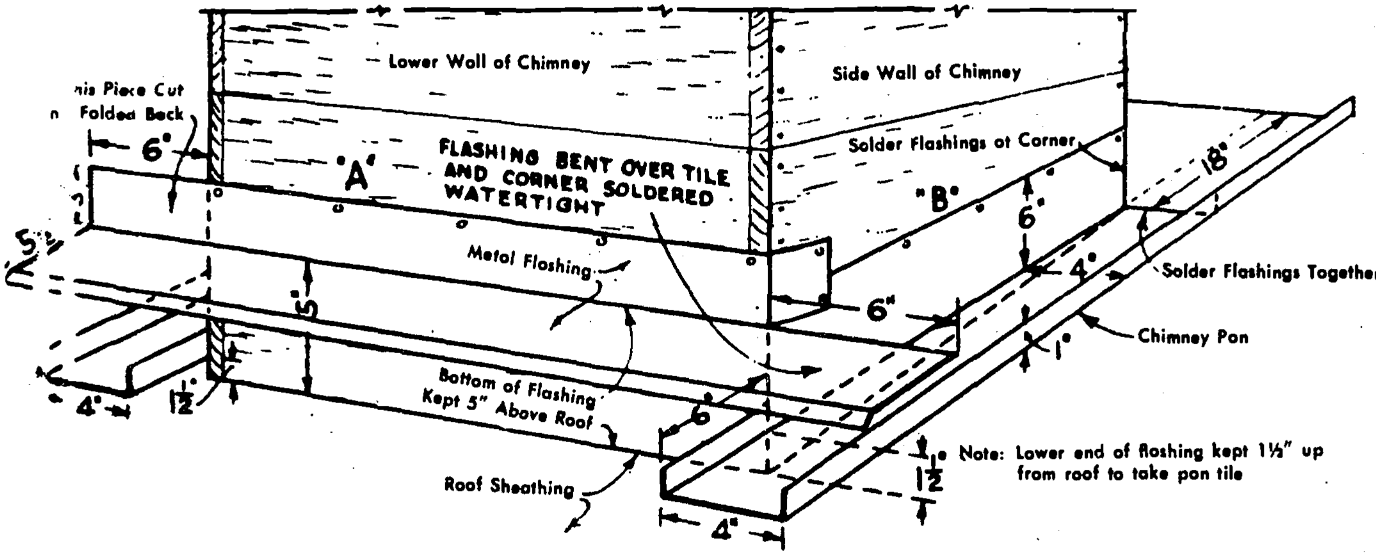
Vertical wall flashing for asphalt concrete topping



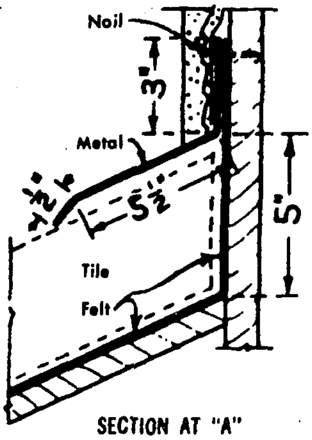
DETAIL U²-U²

1. Base slab and curb
2. Reinforcing strips
3. Membrane
4. Topping slab
5. Filler strip
6. Joint sealer
7. Counterflashing curb
8. Built-up roofing
9. Base flashing
10. Three-course plastic flashing
11. Metal counterflashing and reglet

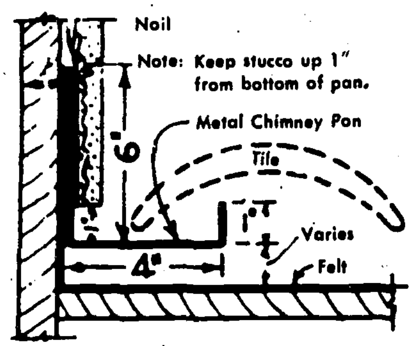
Combination roof and concrete topping flashing



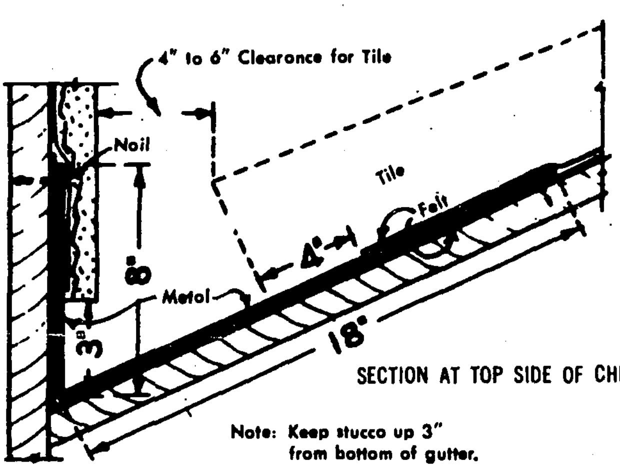
DETAIL V-V



SECTION AT "A"

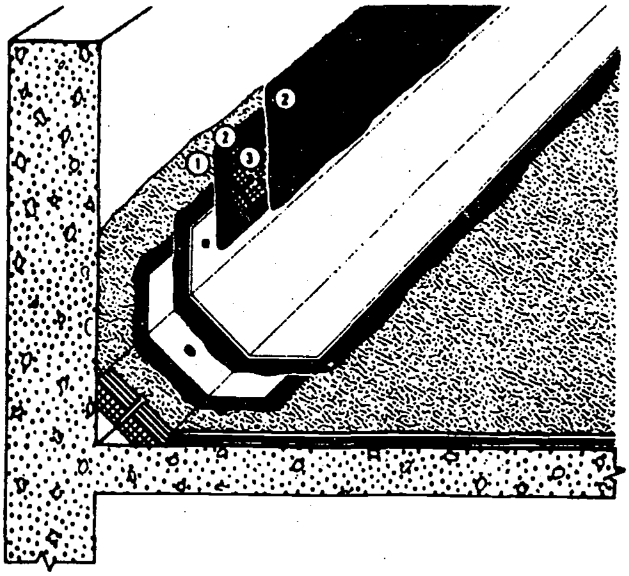


SECTION AT "B"



SECTION AT TOP SIDE OF CHIMNEY

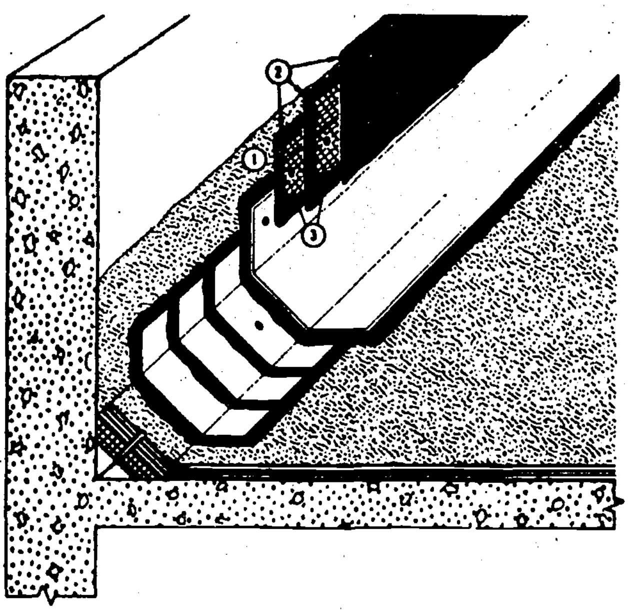
Chimney flashing using channel and chimney pan



1. Asphalt primer
2. Flashing compound (⅛ in. thick)
3. Yellow jacket glass fabric or No. 15 asbestos felt strip

DETAIL W^1-W^1

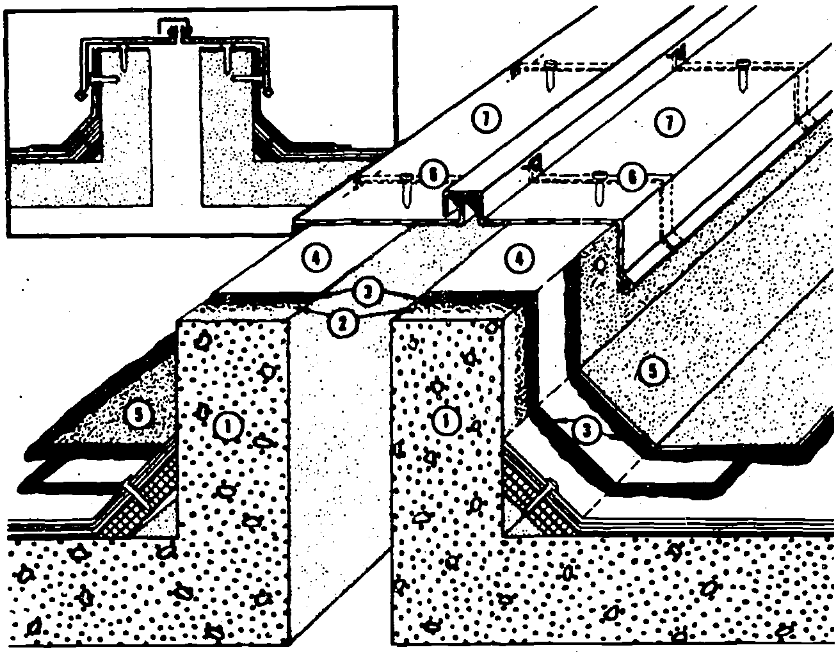
Three-course plastic flashing system



1. Asphalt primer
2. Flashing compound (⅛ in. thick)
3. Yellow jacket glass fabric or No. 15 asbestos felt strip

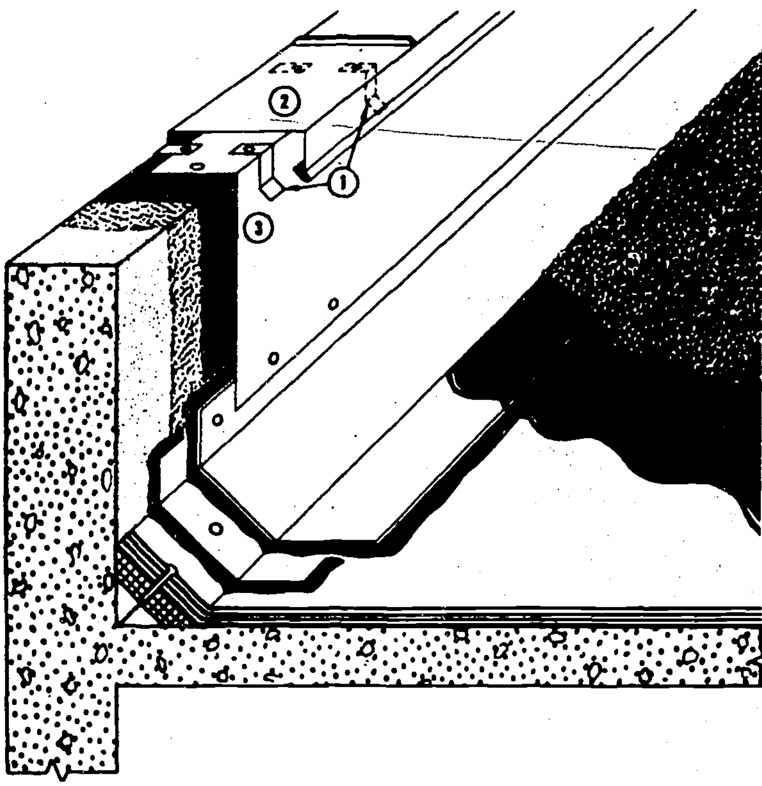
DETAIL W^2-W^2

Five-course plastic flashing system



1. Masonry curbs
2. Asphalt primer
3. Asphalt mopping
4. No. 15 asphalt felt
5. Mineral surfaced capsheet
6. Anchor clips
7. Expansion coping

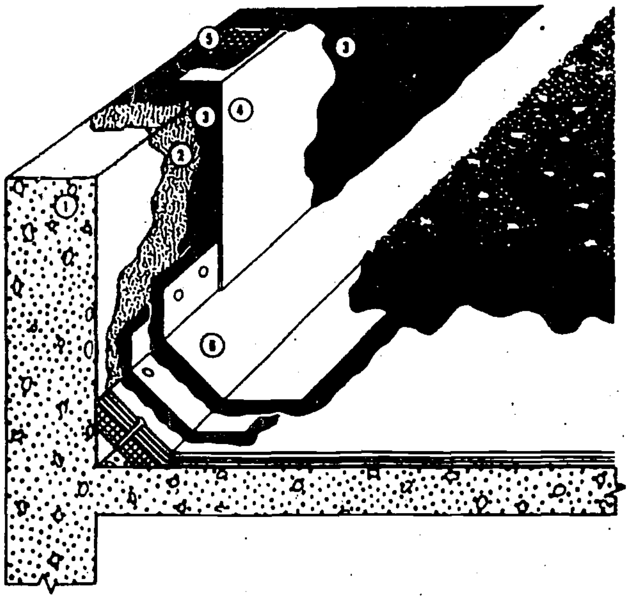
DETAIL X-X



1. Metal holding clip
2. Standing seam metal coping
3. Roofing felt wall covering

DETAIL Y-Y

Expansion joint metal coping



1. Masonry parapet wall
2. Asphalt primer
3. Asphalt mopping
4. 45-lb. asbestos sheet
5. Three-course plastic flashing
6. Base flashing

DETAIL Z-Z

Parapet wall flashing of asbestos felt and hot asphalt

Flexible flashing

CHAPTER XII

PLUMBING

SEWERS AND DRAINS

1. The house or building sewer is that part of the sanitary sewer system beginning just outside the building foundation wall and ending at the main sewer in the street or at the septic tank. The house or building drain is that part of the plumbing system which receives the discharge of all soil and waste stacks in the building and conveys it to the house sewer. It is also called the collection line. It may be underground or it may be suspended from the basement ceiling. The house sewer and house drain must be leakproof and of adequate size to carry off the discharge of all the fixtures in the plumbing installation. If either is too small it may cause overflow in fixtures. The house sewer is generally the same size as the house drain, but in many instances a larger size is used. Cast iron soil pipe is generally used for both house sewer and drain, although bituminized fiber and other man made materials such as the plastics and combinations of plastics and fibers are acceptable substitutes in areas where not prohibited by building codes and ordinances.

2. House Drain.

a. The house drain must be of sufficient size to carry off all the water and waste materials which may be discharged into it at any one time. The minimum allowable size is 3 inches for cast iron soil pipe and most plumbing codes and ordinances require 4 inch pipe as a minimum. Increasing the pipe beyond that computed as required (the minimum 3 inches still applies) does not increase the efficiency of the drain. The passage of liquid and solid waste through a horizontal pipe creates a natural scouring action which is partially lost when the size of the drain pipe is increased above the necessary size. The flow in too large a pipe is shallow and slow, and solids tend to settle to the bottom. The solids may accumulate to such an extent that they cause stoppages in the line. The optimum size of pipe should flow half full under normal use. This would create an efficient natural scouring action and still allow capacity for peak loads.

b. Fixture Unit. The discharge of a plumbing installation is calculated in <u>fixture units</u>. A fixture unit is an arbitrary unit representing the volume of discharge from a lavatory or wash basin in one minute. This volume is approximately $4\frac{1}{2}$ gallons, close to one cubic foot. Fixture unit values for all standard plumbing fixtures have been determined experimentally and the most common are shown in Table 11-1

TABLE 11-1. FIXTURE UNIT VALUES

Fixture	Unit Value
Lavatory or Wash Basin	1
Floor Drain	1
Kitchen Sink	2
Bathtub	2
Laundry Tray	2
Shower	2
Slop Sink	3
Urinal	5
Water Closet	6

c. Pipe Size. Table 11-2 lists the capacity in fixture units of various sizes of pipe for horizontal drain. This table is for cast iron soil pipe or galvanized steel pipe house drains, house sewers and waste and soil branches. When copper tubing (type DWV for above ground use only) is used, it may be one size smaller than indicated by the table. After calculating the total fixture units discharging into a horizontal drain line (branch, house drain or house sewer) and determining the slope of the line the correct size of pipe is selected from Table 11-2.

<u>NOTE</u>: The size of drainage lines must never decrease in the direction of flow.

TABLE 11-2. HORIZONTAL SANITARY DRAIN CAPACITY IN FIXTURE UNITS (CAST IRON AND STEEL PIPE)

Size of Pipe (inches)	Slope (Fall Per Foot in Inches) 1/8	1/4	1/2
	Fixture Units		
$1\frac{1}{4}$	1	1	1
$1\frac{1}{2}$	2	2	3
2	5	6*	8*
3	15**	18**	21**
4	84	96	114
5	162	216	264
6	300	450	600
8	990	1,392	2,220
10	1,880	2,520	3,900
12	3,084	4,320	6,912

* No water closet will discharge into a pipe smaller than 3" (includes DWV type copper tubing).

** No more than two water closets will discharge into any 3 inch horizontal branch, house drain or house sewer. (Some ordinances limit this to one water closet.)

d. Examples:

(1) Assume that a plumbing installation consists of 25 water closets, 22 lavatories, 15 showers, 20 urinals, 2 slop sinks, 2 laundry trays and 4 floor drains. The total discharge in fixture units would be calculated as follows from Table 11-2.

Number of Fixtures	Type of Fixture	Unit Value		Unit Total
25	Water Closet	6	=	150
22	Lavatory	1	=	22
15	Shower	2	=	30
20	Urinal	5	=	100
2	Slop Sink	3	=	6
2	Laundry Tray	2	=	4
4	Floor Drain	1	=	4
		Total Fixture Units		316

(2) Assume that a cast iron house drain to be installed will have a slope of $\frac{1}{4}$ inch per foot. From Table 11-2 it may be seen that the minimum size is 6 inches.

3. Installing the House Sewer.

a. Considerations. The most common procedure for installing the house sewer is to connect the sewer thimble (See Fig. 11-1) to the street sewer and work back, grading upwards, to the house drain. All joints must be supported, and the system must be tested after completion. There are several points to observe when tapping into a vitrified clay or concrete street sewer.

(1) The hole cut in the sewer must be no larger than necessary for the insertion of the sewer thimble.

(2) The sewer thimble must be tapped in above the normal flow level. For example, if the street sewer is 24 inches in diameter, and assuming a 50 percent normal flow, the tap should be made more than 12 inches above the bottom of the sewer pipe.

(3) The sewer thimble must be installed with its discharge parallel to the direction of flow in the sewer.

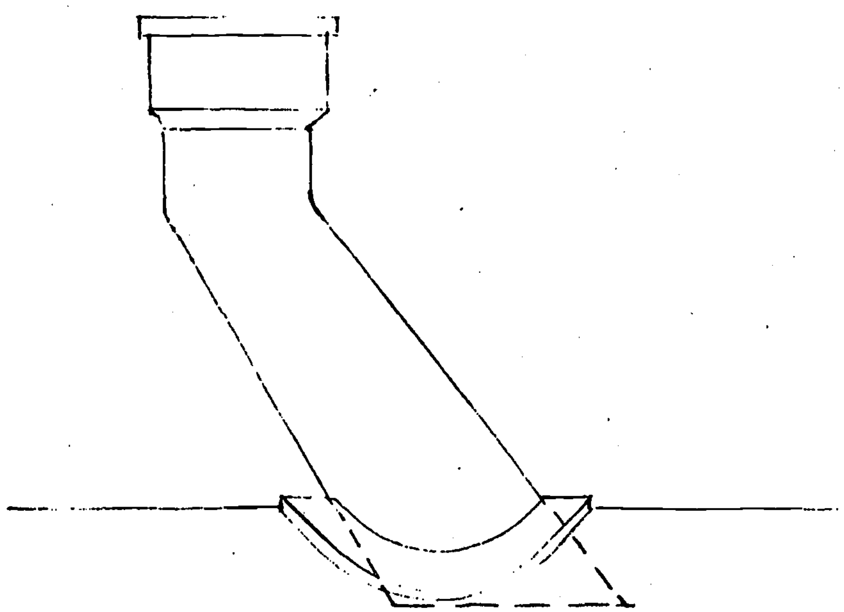


Figure 11-1
Sewer Thimble

b. Procedure.

(1) Tap gently around the circumference of the street sewer to determine the depth of flow. A difference in the sound of the flow indicates the sewage level.

(2) With a cold chisel and hammer, carefully cut a small hole in the center of the proposed location of the sewer thimble.

(3) Enlarge the initial hole into an oval shape approximately the size of the sewer thimble as closely as possible. Try the thimble in the opening frequently to determine when it will fit in without further enlarging the hole.

(4) When the thimble will just fit into the opening, insert it in the proper position and pack oakum around the edges of the flange.

(5) Complete the installation by packing a rich portland cement mortar (1 part sand to 1 part cement) around the thimble. Use plenty of mortar and be sure there is enough on the bottom of the tap as well as on the top and sides. Support the joint until the mortar sets.

4. Grading the House Sewer.

Whenever possible, house sewers are graded to a slope of $\frac{1}{4}$ inch per foot. Lesser or greater slopes are permissable when circumstances require them. Trenches for house sewers may be graded with surveying instruments or by the batterboard method (See Fig. 11-2). For trenching it is convenient to place the batterboards at 8-foot intervals. Each batterboard consists of a stake with a block of wood nailed 2 inches below the top. After setting the first one with the top of its block a convenient distance above the proposed bottom of the trench, succeeding batterboards are driven so that the top of the stake of each one is level with the top of the block on the one preceding it. This level is established with a carpenter's level and plumb on a board over 8 feet long placed on the block of one batterboard and on the top of the stake of the succeeding one. The trench is dug to a constant distance below the line established by the tops of the blocks. Since the batterboards are 8 feet apart and each is 2 inches lower than the one preceding it, the line has a slope of $\frac{1}{4}$ inch per foot. For example, setting the blocks 1 inch below the top of the stakes would give a slope of 1/8 inch per foot; 4 inches would give a slope of $\frac{1}{2}$ inch per foot.

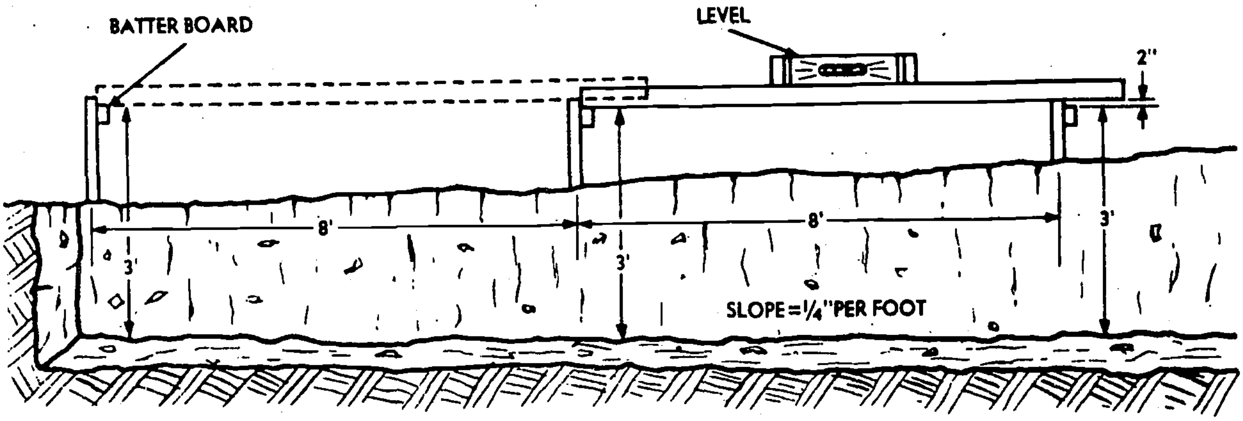


Figure 11-2. Grading the house sewer

5. Supporting Joints.

House sewer and drain piping may be supported adequately by laying it on a base of solid undisturbed earth. This will eliminate future settling which might bring the weight of the pipe sections to bear on the joints. Where the support furnished by the trench is doubtful, each joint should be supported on concrete or cinder block or brick.

STACKS AND BRANCHES

6. Stacks.

The term "stack" is used for the vertical line of soil or waste piping into which the soil or waste branches convey the discharge from fixtures, and which conveys this discharge to the house drain. A waste stack conveys liquid wastes that do not contain human excrement; a soil stack conveys liquid wastes that do. Most buildings do not have separate soil and waste stacks; a single stack known as the soil and waste stack, or simply the soil stack, serves to carry both soil and waste. Stacks and branches may be made of cast iron soil pipe, threaded iron pipe, copper tubing, or, where authorized, plastic. Soil stacks are usually made of cast iron, caulked joint soil pipe. Copper tubing, despite its higher price, is also used frequently for this purpose since it is more easily installed. Branches are usually either threaded galvanized iron pipe with drainage (recessed) fittings or copper tubing.

7. Stack sizing.

The stack is sized in the same way as the building sewer. The maximum discharge of the plumbing installation is calculated in fixture units and this figure applied to Table 11-3 to obtain the proper size stack. Continuing the example in paragraph 2, this chapter (page 208), the 316 fixture units would require a 4-inch stack, if cast iron or steel pipe were used, or a 3-inch stack for copper.

TABLE 11-3. MAXIMUM FIXTURE UNITS PER STACK (CAST IRON AND STEEL PIPE)

Size of Pipe (inches)	Fixture Units Per Stack
3	60
4	500
5	1,100
6	1,900
8	3,600
10	5,600
12	8,400

8. Individual Waste Sizing.

a. Water Closets. The water closet, strictly speaking, has no waste. It is usually connected directly into the stack on a short as possible separate branch of its own terminating in a closet bend. The closet bend is 3 to 4 inches in diameter if cast iron or steel and 3 inches if copper.

b. Closet Bends. The closet bend (Fig. 11-3) is a special fitting inserted into a soil branch to be fitted to the water closet. It may be untapped or have either one or two side taps for waste or vent use. Closet bends are made in several different styles to fit different types of floor flanges. One type (1, Fig. 11-3) has a spigot end for caulking into the soil line and a scored end which fits into the floor flange. The scoring makes it easier to cut the bend to the correct length for a given water closet connection. Another type (2, Fig. 11-3) has a hub which is connected to the floor flange with a sleeve or short length of pipe, and is scored for cutting to size on the end which is caulked into the soil line. Other types may be scored for cutting at both ends or may be of the regular hub and spigot pattern.

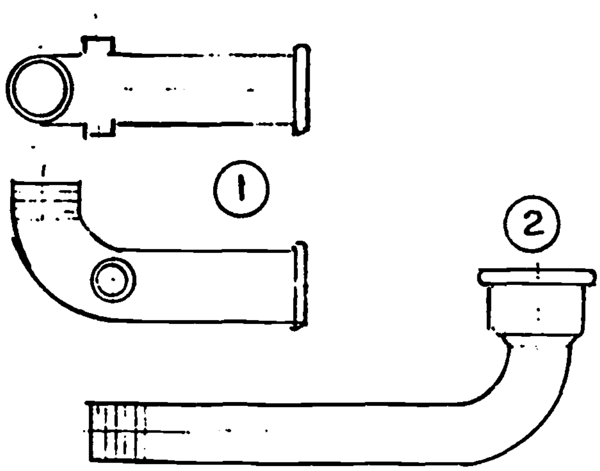


Figure 11-3
Cast Iron Soil Pipe Closet Bends

c. Lavatories. Lavatories are often used for purposes other than washing the hands and face, which is the purpose for which they were designed. For example, they are used for washing the hair and loose hair is often carried down into the waste pipe causing a stoppage. Lavatory drainage is improved by using a minimum of fittings and by eliminating long horizontal runs. Minimum pipe size for lavatory wastes is $1\frac{1}{4}$ inches, but if other than copper is used, $1\frac{1}{2}$ inches will prove more satisfactory.

d. Urinals. Urinals present a particular problem because cigarette butts, cigar stubs, chewing gum and matches are so often discarded in urinals. These foreign materials can easily cause a stoppage. For this reason urinals should be equipped with an effective strainer. Size of waste pipe should be at least 2 inches if cast iron or steel and $1\frac{1}{2}$ inches if copper. Waste pipe for a multiple installation of urinals should be a size or two larger than for a single urinal.

e. Showers. Shower wastes seldom cause trouble since they have a relatively clear water waste flowing through them. The only problem is removal of hair which is usually caught by the strainer in the shower waste. The usual diameter of the waste pipe for a single shower is 2 inches if cast iron or steel and $1\frac{1}{2}$ inches if copper.

f. Laundry Trays. Waste pipes for laundry trays are comparatively trouble free since the laundry tray is usually installed on the lower floor and discharges directly into the building sewer or into the lower portion of the stack. A $1\frac{1}{2}$ inch pipe, cast iron or steel, or $1\frac{1}{4}$ inch copper tubing is adequate for laundry tray waste.

g. Sinks.

(1) Kitchen Sinks. The ordinary kitchen sink requires a $1\frac{1}{2}$ inch cast iron or steel waste pipe. Because of the food wastes which are inevitably flushed into the waste, and particularly when the sink is equipped with a garbage disposal unit, 2 inch cast iron or steel or $1\frac{1}{2}$ inch copper tubing will prove more satisfactory.

(2) Slop Sinks. There are two styles of slop sinks. The trap-to-floor and the trap-to-wall. They are used for disposal of wash water, filling mop buckets and washing out mops. The trap-to-wall type requires a 2 inch waste pipe; the trap-to-floor, a 3 inch. In both cases, if copper tubing is used, a one-size reduction is allowed.

(3) Scullery Sinks. Scullery sinks used in commercial or institutional kitchens are large sheet metal or stainless steel sinks. They are used for washing large pots and pans and for general scouring purposes. The large amount of grease which usually passes through a scullery sink makes a 2 inch waste pipe necessary.

h. Drinking Fountains. Since drinking fountains carry only clear water wastes a $1\frac{1}{4}$ inch waste pipe is suitable.

9. Stack Installation.

The stack (Figure 11-4) is started with a connection to the house sewer using a $\frac{1}{4}$ bend, preferably a long sweep bend to keep back pressure at a minimum. A test T is then connected to the bend with a length of pipe sufficient to raise the test T side opening 12 inches above the finished floor. Additional pipe is added until the desired height for the first branch takeoff is reached. At this point a sanitary T or a combination Y and 1/8 bend is installed. These last two steps are repeated until the fitting for the highest branch line is installed. The extension of the stack above the topmost branch fitting is called the stack vent if it is run through the roof without connecting to the main vent. When it is connected to the main vent it is called the main soil and waste vent which is the usual practice.

10. Main Vent T Installation.

The main vent T is placed in the stack at a point at least 6 inches above the flood level of the highest fixture in the installation. It forms the junction between the main vent and the main soil and waste vent.

11. Inserting Stack Through Roof.

After the main vent T has been installed the main soil and waste vent is inserted through the roof to form the vent terminal. The pipe must be at least equal in size to the stack and should terminate at least 12 inches above the roof. It may be run straight up from the stack or offset. The opening in the roof is made watertight by flashing. Roof flashings are available in a variety of sizes, materials and styles. The type and size will depend on the material and size of main soil and waste vent and on the roof slope. In areas subject to below freezing temperatures, frost closure of the main soil and waste vent at its roof outlet is possible. The moist air coming out of the stack and vent condenses and may freeze when exposed to very low temperatures. To prevent this the pipe may be increased a size or two larger than the stack.

12. Branch Installation.

a. Slope. Horizontal branches are run from the branch takeoff on the soil stack to the various fixtures (Fig. 11-4). Branches should slope up from the stack to the fixture ¼ inch per foot. A 2 foot carpenter's level with a ¼ inch board under one end makes a convenient tool for checking the slope.

b. Cleanouts (Fig. 11-4). These should be installed at the end of long horizontal branches to facilitate clearance of stoppages.

c. Branch Sizing. The size of the branch is established by the number of fixture units connected to it (See Table 11-3). No branch may be larger than the soil or waste to which it is connected.

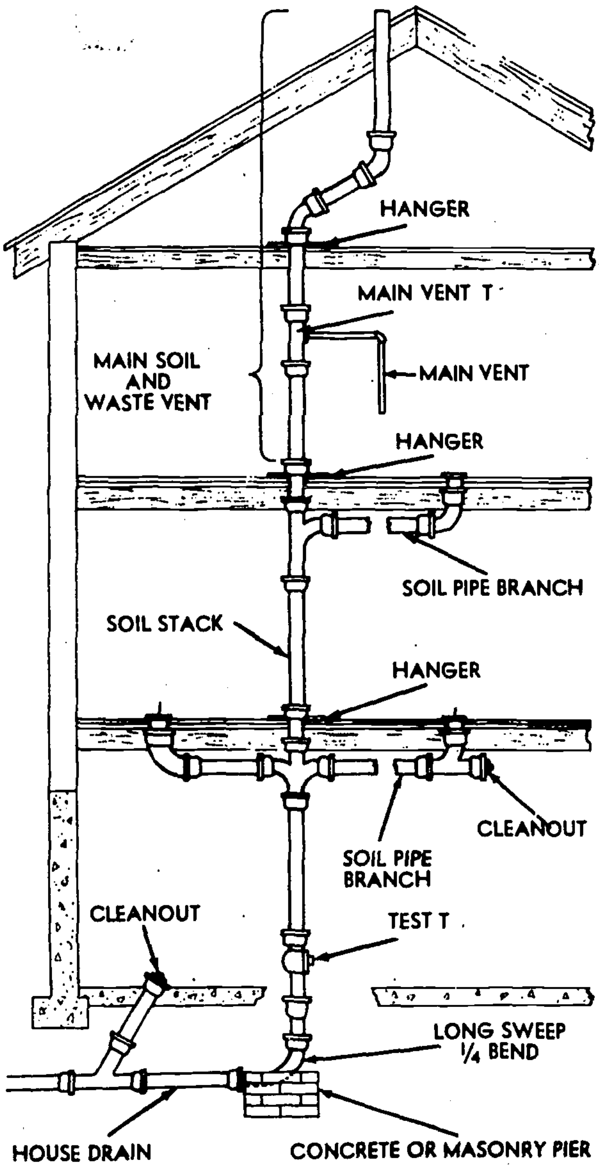


Figure 11-4
Soil Stack and Branches

13. Supporting the Stack and Branches.

Stacks and branches are supported so that the weight of the pipe will not bear on joints which are the weakest points in the line. Cast iron soil pipe stacks and branches should be supported at intervals of not over 5 feet (Fig. 11-5). The bend at the base of the stack should rest on a concrete or masonry pier. Vertical stacks may be supported with special hangers or by placing wood strips under two sides of the hub or by wrapping strap iron around the pipe at the hub and suspending it from joists. Horizontal cast iron branches may be similarly supported. Threaded galvanized iron waste pipe and copper tubing drain and vent lines should be supported every 10 feet.

14. Testing.

a. Preparation. After the waste installation is completed it must be tested to see that all joints are leak-proof. All branches and vent lines are sealed off and a test plug is inserted in the T at the base of the stack (Fig. 11-6). The system is filled with water from the top of the main soil and waste vent and kept filled for at least 12 hours to allow the oakum in joints to expand. (This procedure is omitted for galvanized iron or copper tubing installations). The system is then tested by means of water or air.

b. Water Test. Fill the system with water as in a above. Check for any drop in the water level. If the level drops appreciably check each joint for leaks. During a satisfactory test, the water level in the stack should not fall more than 4 inches in a 30 minute period.

c. Air Test. A special plug through which air may be pumped into the system is required for this test. All openings are closed (after the water has been drained in the case of a cast iron pipe system) and an air pressure of about 5 pounds per square inch (psi), measured by a guage, is applied. An appreciable drop in pressure indicates a leaky joint. In a satisfactory test, the line should hold 5 psi for 15 minutes. Leaks may be located by listening for the sound of escaping air. Where no sound can be detected, and falling pressure indicates a leak, joints may be tested by applying a soap solution to them and looking for bubbles.

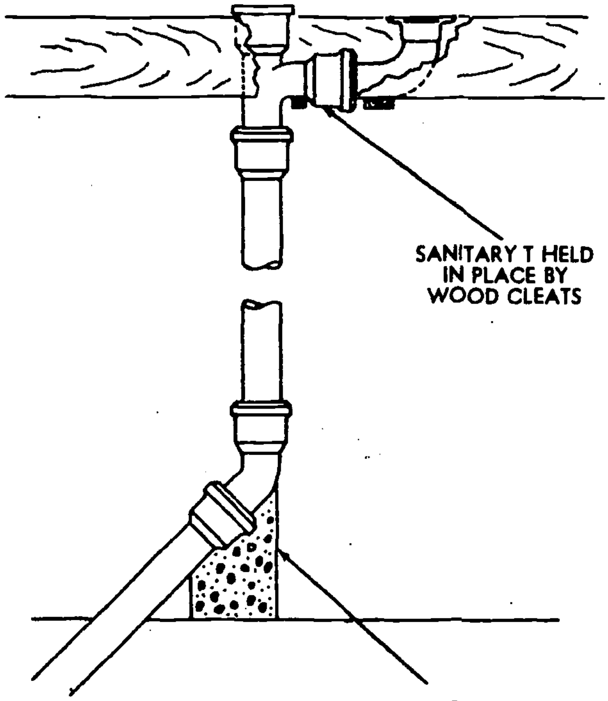


Figure 11-5
Support of Stacks and Branches

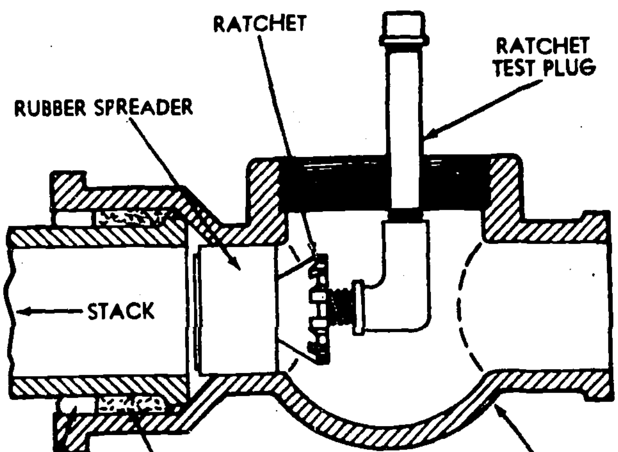


Figure 11-6
Test T with Test Plug Inserted

CRITERIA FOR SELECTION OF TYPE OF DISTRIBUTION OF THE EFFLUENT

	LEACHING CESSPOOL One or more may be used as needed.	SUBSOIL DISPOSAL DRAINS Type 5.1 includes, in addition, collection tile under the distributing tile.	SAND FILTER Rectangular circular or narrow trench types. Open or closed type.
TERRAIN SLOPE OR GRADE	Applicable to any slope.	For level or slight slope.	Applicable to any slope, except filter area to be approximately level.
POROSITY OF SOIL	Soil adjacent to cesspools must be fairly porous below intake. Above may be impervious.	Top 1'–6" to 2'–0" must be fairly porous unless type 5.1 is used, and this may be used with impervious soil.	Soil may be impervious.
GROUND WATER	Water level must be at least 8'–0" below grade at cesspools. Never less than 2'–0" below bottom of cesspools.	Water level 4'–0" below bottom of trench.	Water level approximately 4'–0" below bottom of filter bed.
ORIENTATION AND LOCATION	Not important. Small area required, not less than 15'–0" from building.	If possible place field on southern slope; drains run parallel to contours. Requires large area.	Open type requires placing to leeward and away from buildings; on sunny site. Closed type requires more area than open. Small area required.
FINAL DISPOSAL OF EFFLUENT	No provision necessary.	No provision necessary, except for type 5.1 it is desirable.	Means for final disposal necessary in water course that will not pollute any potable water supply.
MAINTENANCE	Cleaned approximately every 2 years.	Cleaned only when absorbtion ceases. May be years if septic is kept in condition.	When filtering ceases remove and replace top 2".
INITIAL COST	Usually lowest cost.	More expensive than cesspools. type 5.1 is more expensive.	More expensive. Only used where other types are not possible. Open type cheaper than closed.

DESIGN OF SEWAGE DISPOSAL SYSTEMS

EXPLANATION OF TABLES BELOW

"No. of persons served" in first column refers to "Residential Work". To use tables for other types of buildings multiply this "No. of Persons Served" by the appropriate conversion factor listed in the table directly below.

TYPE OF BUILDING	GALS. OF SEWAGE PER PERSON	CONVERSION FACTORS
Residential	50	1.0 (Unity)
Camps	25	.5
Summer Cottages, small farms	40	.8
Day Schools, factories (no kitchens or showers)	15 to 25	.3 to .25
Day Schools, factories with kitchens and showers	30 to 50	.6 to .5
Institutions except hospitals	100	2.0
Hospitals	150 to 250	3.0 to 5.0

METHOD OF RELATIVE ABSORPTION DETERMINATION

Dig or bore 8" to 12" Dia. hole to a depth of 6" below bottom of proposed trench or cesspool. Presoak hole & allow to drain away. Fill hole to depth of 6" and record time it takes water to drop 1". Repeat minimum three times until 1" drop for two successive tests give approximately equal results. Last test will be stabilized absorption rate.

MINUTES REQ'D FOR WATER TO DROP 1 INCH	RELATIVE ABSORPTION	DISPOSAL METHOD RECOMMENDED
0 to 5	Rapid	Cesspool or Drains
6 to 10	Medium	Cesspool or Drains
11 to 15	Slow	Cesspool or Drains
16 to 29	Semi-impervious	Dr'ns-Collect & Filter
30 & Over	Impervious	Filter

SEPTIC AND SIPHON TANKS

NO. OF PERSONS SERVED	SEPTIC TANK					SIPHON TANK * NOT ESSENTIAL FOR THESE SIZES			SIPHON		CONCRETE THICKNESS		
	GALS. WORKING CAPACITY	LENGTH	WIDTH	AIR SPACE	LIQUID DEPTH	LENGTH	WIDTH	DEPTH	SIZE	DRAWING DEPTH	WALLS	TOP	BOTTOM
1–7	750	7'–6"	3'–6"	1'–3"	4'–0"	3'–6"	3'–6"	3'–0"	3"	1'–1"	6"	4"	6"
8–10	1000	8'–0"	4'–0"	1'–3"	4'–4"	4'–0"	4'–0"	3'–0"	3"	1'–1"	6"	4"	6"
11–15	1500	9'–6"	5'–8"	1'–3"	4'–6"	4'–8"	4'–8"	3'–6"	4"	1'–5"	8"	5"	8"

Capacity of above septic tanks is based on 100 gallons flow of sewage per person for 24 hours, and is for residential work. To design tanks of larger sizes refer to local regulations. Length of tanks should be approximately twice width. Minimum depth 4'–0".

When purchasing a prefabricated septic tank, require manufacturers guarantee that the tank will treat the gals. capacity as above calculated within a 24 hour period.

If garbage destructor is used & discharges into septic tank, increase capacity for additional sludge up to 50%.

LEACHING CESSPOOL DISPOSAL

NO. OF PERSONS SERVED	FOR RAPID ABSORPTION			FOR MEDIUM ABSORPTION			FOR SLOW ABSORPTION		
	NO. OF CESS-POOLS	DIA.	DEPTH	NO. OF CESS-POOLS	DIA.	DEPTH	NO. OF CESS-POOLS	DIA.	DEPTH
1–7	1	8'-0"	8'-0"	2	6'-0"	7' 0"	2	8'-0"	7' 0"
8–10	2	6'-0"	7'-0"	2	8'-0"	7'-0"	2	8'-0"	10'-0"
11–15	2	8'-0"	8'-0"	2	10' 0"	8'-0"	3	10'-0"	8' 0"

Capacity of above cesspools based on 100 gals. flow of sewage per 24 hours, and is for residential work. Total absorptive area = Area of walls (below inlet) + area of bottom.
Total absorptive area = $2\pi R \times \text{height} + \pi R^2$

SUBSOIL DISPOSAL DRAINS — 4"

NO. OF PERSONS SERVED	LINEAL FEET ABSORPTION		
	RAPID	MED.	SLOW
1–7	160	150	195
8–10	210	200	260
11–15	320	300	390

Assuming 2' wide absorption trench for rapid absorption soil. 3' wide absorption trench bottom for medium and slow absorption soil.

SAND FILTERS

NO. OF PERSONS SERVED	AREA REQU'D IN SQ. FT.	
	OPEN	CLOSED
1–7	250	655
8–10	335	870
11–15	500	1310

These areas are based on 1.15 gal./sq.ft. per day for closed and 3 gal./sq.ft. per day for open.

CHAPTER XIII

DOORS AND HARDWARE

Doors

Doors are a lot more complicated than they look, especially from the inside. Wood doors, for example, are as smooth as most steel doors. They are used more frequently because wood adds a popular warm charm and can be sawed and drilled easily. Custom steel doors and standard steel doors are also difficult to tell apart -- the face sheets are often identical. Standard steel doors are specified more often because they are made-to-order for specific installation. Standard steel doors are selected because of their reliability; they are pre-engineered and machine-manufactured to quality controlled standards. Fabricating distributors throughout the country modify these doors in accordance with architectural specifications.

Shown in Figure 12 (a) a solid-core wood door; Figure 12 (b) a custom steel door utilizing vertical stiffners that slide together with pressed paper between; and Figure 12 (c) another custom steel door whose vertical stiffners are tack welded together at the bottom with corrugated asbestos placed between. Wood doors are manufactured in two basic types: hollow core and solid core. Wood doors are also fire rated and can be utilized for that purpose if specifically engineered and designed for that particular use.

This chapter will deal primarily with steel doors and frames.

There are important differences in steel doors, too. Shown in Figure 12 (d) are three standard types, cut-away to show inner construction. Figure 12 (d)(1) shows a honeycomb core, a fiber produce bonded to both face sheets. Figure 12(d)(2) shows vertical steel stiffners welded to face sheets with strips of insulation placed between. Figure 12(d)(3) shows horizontal steel stiffners welded to face sheets but not together.

Doors are selected for purpose as well as appearance and durability. Glass in a door restricts its use as a fire rated door and local code requirements vary throughout the country -- local authorities control the use of label doors and should be consulted during the writing of specifications. Doors and frames for Class A (3 hours) openings must be specified as a unit.

For Class B openings ($1\frac{1}{2}$ hours) the maximum exposed glass area is 100 square inches, with no dimension exceeding 12 inches. This is the total area for either a single or double door installation. The standard detail for this glass area is 10" x 10" vision light in a single door, or one door of a double door installation, or a 5" x 10" vision light in both leafs of a double door.

For Class C and E openings (3/4 hour) the maximum exposed glass area cannot exceed 54 inches in any dimension. Standard details for this glass area are determined by the size of the door; one or more muntins, depending upon Underwriters Laboratory (UL) requirements, used to subdivide the total glass area.

Hardware

Door Swings: See Figure 12-4

Locksets: See Figure 12-5

Door Closers: See Figure 12-6

Hinges: See Figure 12-6

Miscellaneous Hardware: See Figure 12-7

Cover Plates: See Figure 12-7

Door Stops: See Figure 12-7

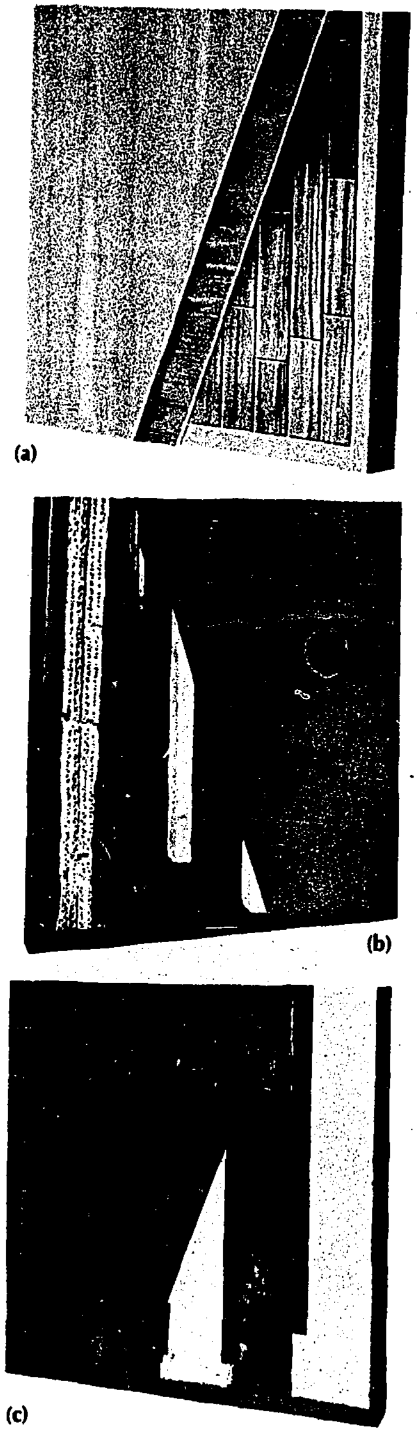


FIGURE 12 (a)(b)(c)

FIGURE 12(d)(1)(2)(3)

HOW TO DETERMINE HAND AND SWING

1. The hand of a door is determined from the outside.
2. The outside of an entrance door is the street side.
3. The outside of a room door is the corridor side.
4. The outside of a communicating door is the side from which hinges are not visible with door closed.
5. The outside of a closet door is the room side.
6. The key side (x) will be the outside, unless otherwise specified.

ON PAIRS OF DOORS KEY SIDE

Right hand leaf is always active except when panic bolts Pt. 9590 and 9591 are used.

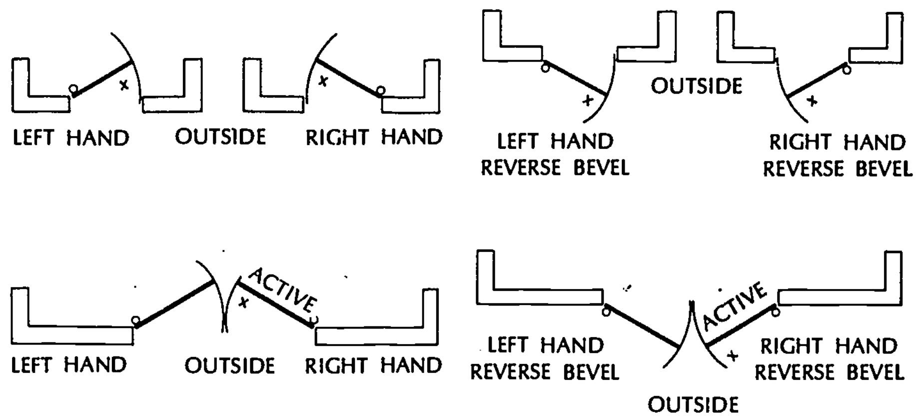


FIGURE 12-4 Door Swings

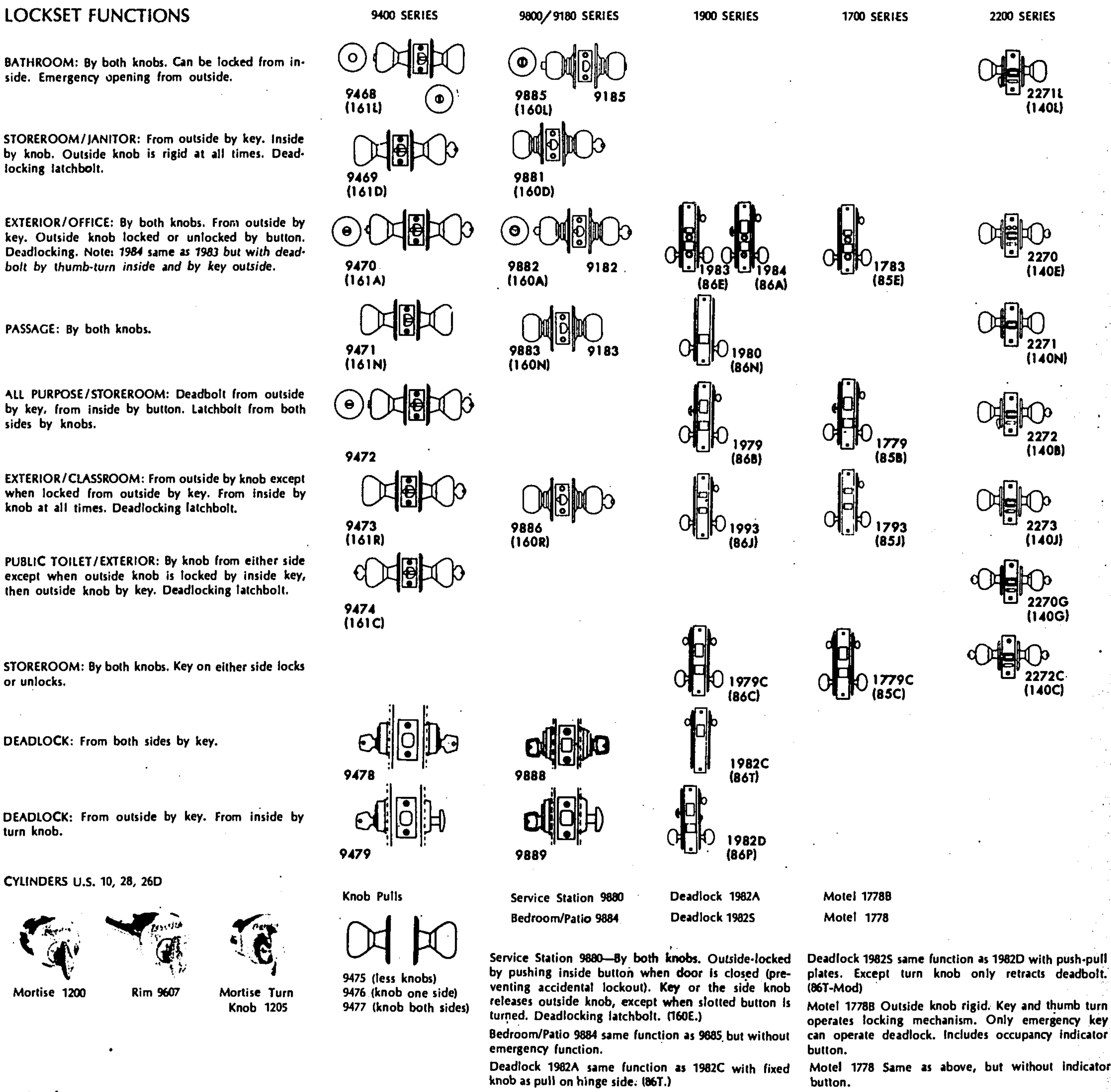


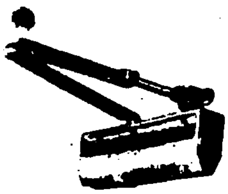
FIGURE 12-5 Locksets

DOOR CLOSERS

RECTANGULAR CLOSERS

2550 Series/2050 Series

2550 Series



2050 Series

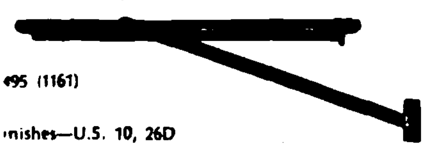
The 2550 and 2050 Series are engineered to give lasting performance under the most exacting conditions. The compact, heavy duty closers offer complete door control with absolutely no sacrifice in efficiency when compared to standard closers of equal size.

- Close-grained, high strength cast iron case with thick walls.
- Heat-treated rack and pinion parts, plus needle bearings.
- Minimum life of helical spring—1,000,000 cycles.
- Hand: When mounted on a door, closer is handed, either left hand (LH) or right hand (RH), as viewed from the push side of the door. The opposite applies when the closer is mounted on a bracket.
- Finishes: BRZ (Bronze) EN (Aluminum).

door opening width	1¾" doors interior	1¾" doors exterior	1⅜" doors interior	1⅜" doors exterior
2'-0" & 2'-4"	2052	2053		
2'-6"	2552	2553	2052	2053
2'-8"		2054	2552	2553
3'-0"	2053	2554		
3'-4"	2553	2574		
3'-6" & 3'-8"	2054	2575	—	—
4'-0"	2554	2576		

Use bracket 2550 with closers 2552, 2553 and 2554.
Use bracket 2570 with closers 2574, 2575 and 2576.
Use bracket 2050 with all 2050 Series closers.

OVERHEAD DOOR HOLDER AND SHOCK ABSORBER



495 (1161)

Finishes—U.S. 10, 26D

For single-acting doors hung on hinges. Encased shock absorber cushions outward swing of door. 90° hold-open by upward turn of control handle. Surface applied. Specify door width. hand-left or right.

STANDARD CLOSERS

1460 Series

- The 1460 Line is the standard of quality. Its reliability has been proven over the years.
- Universally handed.
- Rack and pinion construction with helical spring.
- Finishes: BRZ (Bronze) EN (Aluminum).

door opening width	1¾" doors interior	1¾" doors exterior	1⅜" doors interior	1⅜" doors exterior
2'0" & 2'4"		1462		1461
2'-6"	1461		1461	
2'-8"				1462
3'-0"	1462			
3'-4"		1463		
3'-6"				
3'-8"	1463	1464		
4'-0"				

Use bracket 1765 with closer 1461
Use bracket 1366 with closer 1462
Use bracket 1367 with closer 1463
Use bracket 1368 with closer 1464

Closer Arms—Standard & Rectangular

Regular Arms:	Allows doors to open 140°.
Hold-open Arm:	Holds door open in any position between 65° to 135°. Easily adjusted.
Fusible-link Hold-open Arm:	Holds door open in any position from 65° to 135°. Fusible-link melts when exposed to 160°F, thus causing door to close automatically.
Parallel Arm:	Allows door to open 180°. Closer fastened to door. Eliminates need for bracket.

Fenestra is local everywhere

HINGES

U.S. 10, 26D, Prime

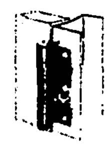
1¾" Doors
Full Mortise Type

643
Plain
bearing
steel
(T2127)

643A
2 Ball
bearing
steel
(T2107)

643B
2 Ball
bearing
bronze
(T2106)

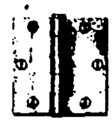
Half Mortise Type



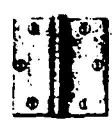
S643
Plain
bearing
steel
(T2145-Mod)

S643A
2 Ball
bearing
steel
(T2145-Mod)

1⅜" Doors
Full Mortise Type



2389
Plain
bearing
steel
(T2127-Mod)



2389A
2 Ball
bearing
steel
(T2107-Mod)

2389B
2 Ball
bearing
bronze
(T2106-Mod)

FIGURE 12-6 Door Closers & Hinges

MISCELLANEOUS HARDWARE

PUSH AND PULL PLATES

15" x 3½", Wrought plate .050 Cast grip.
Finishes—U.S. 10, 28, 26D

1490A
(Fed. 451)

2250A
Cut for cyl.

1491A
(Fed. 465R)

2251A
Cut for cyl.

450
(Fed. 455)

450C
Cut for cyl.

451
(Fed. 465)

451C
Cut for cyl.

16" x 4" Extruded
Finishes—U.S. 10, 28, 26D

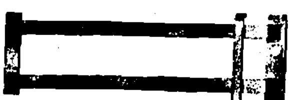
1490A EX
(Fed. 450)

2250A EX
Cut for cyl.

1491A EX
(Fed. 460)

2251A EX
Cut for cyl.

PUSH AND PULL BARS

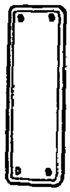


1799—Complete set for each side of door. When lock is required, use 1982C.

2399—Similar to 1799, except has single bar with attaching plate only on lock stile.

Finishes—U.S. 10, 28.

COVER PLATES



1985

Size—7¾" x 2¼"
Wrought plate to cover 1900 lock machine in door.

Finishes—U.S. 10, 28.

1986—Same as 1985, except with pull grip.

THRESHOLDS

2325

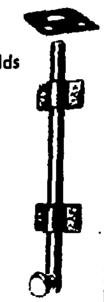
5" width.
Finishes—Extruded aluminum or bronze.

2333—(833A)

5" width. Integral stop provides weather protection.
Finishes—Extruded aluminum or bronze.

HEAD AND FOOT BOLT

1893—(F 1061)



⅜" rod. Surface applied. Holds inactive leaf or pair of doors in a secure position.

Finishes—U.S. 10, 26D, CAD.

KICK PLATES

2343—(1224 to 1227)

Square corners, edges not beveled. Oval head screws furnished. Sizes 6" and 8".

Finishes—U.S. 10, 28, 32D and plastic.

FLUSH BOLTS—MORTISE TYPE

2109A — For U.L. doors (1045).
Conforms to A.S.A. specifications.
Finishes — U.S. 10, 28, 26D.

2409A—(1046).
Finishes—U.S. 10, 28.

Lever extends or retracts bolt head. For use on pairs of doors to lock inactive door at top or bottom, using two bolts. Bolts mortised in edge of door.

DOOR STOPS

Floor Type

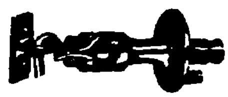
9493 (1329E)
Finishes—U.S. 10, 26D.
With holder. Lead screw anchors.

9494 (1328E)
Finishes—U.S. 10, 26D.
Lead screw anchors.

9495 (1328)
Same as 9494, except furnished with wood screws.

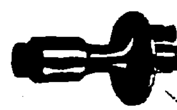
9496 (1330A)
Finishes—U.S. 10, 28, 26D. Wood screws in lead shields.

Base Type



9461 (1321-E).
Finishes—U.S. 10, 26D. With holder. Lead screw anchors.

9462 (1321).
Same as 9461. Except furnished with wood screws.



9459 (1320-E).
Finishes—U.S. 10, 26D.
Lead screw anchors.

9460 (1320).
Same as 9459, except furnished with wood screws.

WALL BUMPERS

9464. Concave, concealed screws. Toggle bolt attachment. 2¾" dia.

9464A. Concave, concealed screws. Expansion shield attachment. 2¾" dia.

9465. Convex, concealed screws. Toggle bolt attachment. 2¾" dia.

9465A. Convex, concealed screws. Expansion shield attachment. 2¾" dia.

Finishes—U.S. 10, 28, 26D.

FIGURE 12-7 Miscellaneous Hardware
Cover Plates
Door Stops

CHAPTER XIV

PAINTS AND PROTECTIVE COATINGS

A knowledge of the types of materials used for painting is useful in determining their capabilities and limitations. There are sound reasons for the existence of each coating specification and these become more apparent with some insight into the composition of the various types specified. The information presented in this chapter is to aid the inspector to understand why a particular coating is specified and explain why it is best suited for the particular combination of conditions present, i.e., the substrate, painting conditions, finish desired and the environment to be withstood by the applied finish.

Most paints are based on a film former or binder which is either dissolved in a solvent or emulsified in water. Upon application of the product in a relatively thin film, it will dry or cure to form a dry, tough coating. Solutions of such binders in solvent may be called by various names, e.g., clear finishes, varnishes if they dry by oxidation, or lacquers if they dry by evaporation. Opaque pigments or colors are dispersed in the binder. The product, which will produce an opaque white or colored film, is called a paint. Pigment concentration can also be varied to produce a high gloss, a semigloss or lusterless (flat) finish.

Special pigments, e.g., red lead and zinc chromate, can be used to provide corrosion resistance in primers. Metallic pigments can be added to varnishes to produce metallic coatings such as aluminum paints. The major performance characteristics of the coating depend generally on the type of binder used. The principal binders used in the paint materials discussed in this section are described only with the reasons for their use, their superior characteristics and their deficiencies. No attempt has been made to discuss their analytical compositions in any detail since this would be of little value to the inspector. The paint binders discussed are listed in alphabetical order for ease of reference.

Alkyd. Alkyd binders being discussed are oil modified phthalate resins which dry by reacting with oxygen from the surrounding air. Alkyd finishes are usually of the general purpose type, are economical and are available as clear or pigmented coatings. The latter are available in flat, semigloss and high gloss finishes and in a wide range of colors. They are easy to apply, and, with the exception of fresh (alkaline) concrete, masonry and plaster, may be used on most surfaces which have been moderately cleaned. Alkyd finishes have good color and gloss, and retain these characteristics well in normal interior and exterior environments. Their durability is excellent in rural environments, but only fair in mildly corrosive environments (see Table 2). Alkyd finishes are also available in odorless formulations for use in hospitals, kitchens, sleeping areas and other places where odor during painting might be objectionable.

Cement. Portland cement mixed with several ingredients acts as a paint binder when reacted with water. The paint is supplied as a powder to which water is added before use. Cement paints are used on rough surfaces such as concrete, masonry and stucco. They dry to form hard, flat, porous films which permit water vapor to pass through readily. Since cement paints are powders, they can also be mixed with masonry sand and less water to form filler coats to smooth rough masonry before applying other paints. Cement paints can be used on fresh masonry and are economical. The surface must be damp when they are applied, and must be kept damp for a few days to obtain proper curing. They should not be used in arid areas. When properly cured, cement paints of good quality are quite durable; when improperly cured, they chalk excessively on exposure and then present problems in repainting.

Epoxy. The epoxy binders discussed are made up of two components: an epoxy resin and a polyamide hardner, which are pre-mixed before use. When mixed the two ingredients react to form the final coating. These paints have a limited working pot life, usually a working day. Anything left at the end of the day must be discarded. Epoxy paints can be used on any surface and can be applied at high solids, thus producing high film build per coat applied. The cured film has outstanding hardness, adhesion, flexibility and resistance to abrasion, alkali and solvents, as well as being highly corrosion-resistant. Their major uses are as tile-like glaze coatings for concrete and masonry, and for the protection of structural steel in corrosive environments. Their cost per gallon is high, but this is offset by the reduced number of coats required to get adequate film thickness. Epoxy paints tend to chalk on exterior exposure so that low gloss levels and fading can be anticipated; otherwise, their durability is excellent.

Epoxy-Coal Tar. Coal tar is often added as an ingredient of epoxy paints, resulting in a significant decrease in cost with relatively minor effect on corrosion resistance. Color choice is limited because of the black color of the coal tar. It is used primarily for interior and submerged surfaces.

Inorganic. The major inorganic binders used in paints are sodium, potassium, lithium and ethyl silicates. These binders are used in zinc dust pigmented primers, in which they react with the zinc metal to form very hard films. These films are extremely resistant to corrosion in humid or marine environments. Many of these primers also contain substantial concentrations of lead oxides which react with the silicates in conjunction with the zinc to form an even more corrosion resistant coating.

Latex. Latex paints are based on aqueous emulsions of three basic types of polymers: polyvinyl acetate, polyacrylic and polystyrene-butadiene. They dry by evaporation of the water, followed by coalescence of the polymer particles to form tough, insoluble films. They have little odor, are easy to apply, and dry very rapidly. Interior latex paints are generally used either as a primer or finish coat on interior walls and ceilings whether made of plaster or wallboard. Exterior latex paints are used directly on exterior (including alkaline) masonry or on primed wood. They are non-flammable, economical and have excellent color and color retention. Latex paint films are somewhat porous so that blistering due to moisture vapor is less of a problem than with solvent thinned paints. They do not adhere readily to chalked or dirty surfaces, nor to glossy surfaces. Therefore, careful surface preparation is required for their use. Latex paints are very durable in normal environments, at least as durable as oil paints.

Oil. Linseed oil is the major binder in oil house paints. These paints are the oldest type of coatings in use and have the longest history of performance. They are used primarily on exterior wood and metal since they dry too slowly for interior use and are sensitive to alkaline masonry. Oil paints are easy to use and give high film build per coat. They also wet the surface very well so that surface preparation is less critical than with other types of paints for metal. They are recommended for hand cleaned iron and steel. Oil paints are not particularly hard or resistant to abrasion, chemicals or strong solvents, but they are durable in normal environments.

Oil-Alkyd. Linseed oil binders are often modified with alkyd resins in order to reduce drying time, to improve leveling, hardness, gloss and gloss retention, and to reduce fading, and yet maintain the brushability, adhesion and flexibility of the oil. One end use is in trim paints which are applied to exterior windows and doors. Since these areas are relatively small and painted in solid colors rather than tints, they require better leveling, gloss retention and fade resistance than the rest of the exterior walls. Also, these areas are subject to some handling, and, therefore require faster drying and harder finishes. Oil-alkyd paints are also used on structural steel when faster drying finishes are desired. However, somewhat better preparation of the surface is required than with oil paints.

Oleoresinous. These binders are made by processing drying oils with hard resins. They generally are used either as spar varnishes or as mixing vehicles to be added to aluminum paste to produce aluminum paints (see Phenolic below). Alkyd finishes are often called oleoresinous because a drying oil is combined with the alkyd (phthalate) resin. Alkyd finishes usually are preferred where better color retention is desired.

Phenolic. Phenolic binders are made by processing a drying oil with a phenolic resin and are thus a class of oleoresinous binders. They may be used as clear finishes or pigmented in a range of colors in flat (lusterless) and high gloss finishes. The clear finishes may be used on exterior wood and as mixing vehicles for producing aluminum paints. The durability of the clears is very good for this class of finishes (1 to 2 years); the durability of the aluminum paints is excellent. Phenolic paints are used as topcoats on metal for extremely humid environments and as primers for fresh water immersion. These paints require the same degree of surface preparation as alkyds but are slightly higher in cost than alkyds. Phenolic coatings have excellent resistance to abrasion, water and mild chemical environments. They are not available in white or light tints because of the relatively dark color of the binder. Furthermore, phenolics tend to darken during exposure.

Phenolic-Alkyd. Phenolic and alkyd binders are often blended to combine the hardness and resistance properties of the phenolics with the color retention of the alkyds. This may be done either by blending phenolic varnish with the alkyd vehicle or by addition of phenolic resin during processing of the alkyd resin.

Rubber Base. So-called rubber base binders are solvent thinned and should not be confused with latex binders which are often called rubber-base emulsions. Four types are available: (1) chlorinated rubber; (2) styrene-butadiene; (3) vinyl toluene-butadiene; and (4) styrene-acrylate. They are lacquer type products and dry rapidly to form finishes which are highly resistant to water and mild chemicals. Recoating must be done with care to avoid lifting by the strong solvents used. Rubber-base paints are available in a wide range of colors and levels of gloss. They are used for exterior masonry, also, for areas which are wet, humid or subject to frequent washing, e.g., swimming pools, wash and shower rooms, kitchens and laundry rooms. Styrene-butadiene, when combined with chlorinated plasticizers and silicone resins, is used to produce high heat resisting ready-mixed aluminum paints.

Silicone. Silicone binders are used in two ways: (1) for water repellents, and (2) for heat resistant finishes.

(1) Water repellents. Dilute solutions (5% solids) of silicone resin are of temporary help in reducing water absorption when applied to unpainted concrete or masonry such as brick or stone. They usually do not affect the color or appearance of the treated surface. Cracks and open joints must be repaired before water repellents are applied.

(2) Heat resistant finishes. Heat resistant organic finishes containing a high concentration of silicone resins, when pigmented with aluminum, have the ability to withstand temperatures up to 1200°F.

Silicone Alkyd. The combination of silicone and alkyd resins results in an expensive but extremely durable coating for use on smooth metal.

Urethane. Two types of urethane finishes are discussed: (1) Oil-modified urethanes, and (2) oil-free, moisture-curing urethanes. Both are used as clears but the oil free type is also available pigmented.

(1) Oil-Modified Urethanes. These are similar to phenolic varnishes, although more expensive, but have better initial color and color retention, dry more rapidly, are harder and have better abrasion resistance. They can be used as exterior spar varnishes or as tough floor finishes. Oil-modified urethanes can be used on all surfaces. In common with all clear finishes, they have limited exterior durability.

(2) Oil-Free, Moisture-Curing Urethanes. These are the only organic products presently available which cure by reacting with moisture from the air. They also are unique in having the performance and resistance properties of two-component finishes yet are packaged in single containers. Moisture-curing urethanes are used in a manner similar to other one package coatings except that all containers must be kept full to exclude moisture during storage. If moisture is present in the container, the urethane will gel.

Vinyl. Lacquers based on modified polyvinyl, chloride resins are used on steel where the ultimate in durability under abnormal environments is desired. They are moderate in cost but have low solids and require the most extensive degree of surface preparation to secure a firm bond. Because of their low solids, vinyl finishes require numerous coats to achieve adequate dry film thickness so that the total cost of painting is higher than with most other paints. Since vinyl coatings are lacquers, they are best applied by spray and dry quickly, even at low temperatures. Recoating must be done with care to avoid lifting by the strong solvents which are present. In addition, these solvents present an odor problem. Vinyls can be used on metal or masonry but are not recommended for use on wood. They have exceptional resistance to water, chemicals and corrosive environments but are not resistant to strong solvents.

Vinyl-Alkyd. The combination of vinyl and alkyd resins offers a compromise between the excellent durability and resistance of the vinyls with the lower cost, higher film build, ease of handling and adhesion of the alkyds. They can be applied by brush or spray and are widely used on structural steel in marine and moderately severe corrosive environments.

Comparison of Paint Binders. Tables 1, 2 and 3 list the relative properties of the major and more common binders as follows:

Table 1 - Application Properties

Table 2 - Use and Service

Table 3 - Film Properties

Table 4 summarizes the outstanding properties from these tables. Properties of the following binders are not included but can be estimated to be similar to those listed as follows:

Oil-Alkyd	= Oil + Alkyd
Oleoresinous	= Similar to alkyds but with less color retention
Phenolic-Alkyd	= Phenolic + Alkyd
Oil-Modified Urethane	= Phenolic + Alkyd
Vinyl-Alkyd	= Vinyl + Alkyd

Legend Used in Tables 1 thru 3
Comparison of Paint Binders

MS—Mineral spirits
Ar—Aromatic hydrocarbon solvents, e.g., xylene
Mod—Moderate
Cons—Considerable
Oxygen—Dries by reaction with oxygen from the air
Chem—Cures by chemical reaction
Coales—Dries by coalescence of latex particles
Evap—Dries by solvent evaporation
Moisture—Cures by reaction with moisture from the air
Min. Surf. Prep.—Minimum surface preparation
EX—Excellent
G—Good
F—Fair
P—Poor
V—Very
NR—Not recommended
X—Not applicable

Table 1. Comparison of Paint Binders
Application Properties

	Alkyd	*Cement*	*Epoxy*	*Latex*	*Oil*	*Phenolic*	*Rubber*	*Moisture-Curing Urethane*	*Vinyl*
Solvents	MS	Water	Lacquer	Water	MS	MS+Ar	MS+Ar	Lacquer	Lacquer
Brushability	G	G	F	EX	EX	G	F	F	Spray
Odor	[1]Mild	None	Strong	V. Mild	Mild	Mod	Mod	Strong	Strong
Method of Cure	Oxygen	Chem	Chem	Coales	Oxygen	Oxygen	Evap	Moisture	Evap
Speed of Dry:									
50°F to 90°F	G	G	G	EX	F	G	EX	EX	EX
Below 50°F	F	F	P	P	P	F	G	G	G
Film Build/Coat	G	EX	EX	G	EX	G	G	EX	F
Safety (Personnel)	G	EX	F	EX	G	G	G	F	F

[1] Very mild for odorless type

Table 2. Comparison of Paint Binders
Use and Service

	Alkyd	*Cement*	*Epoxy*	*Latex*	*Oil*	*Phenolic*	*Rubber*	*Moisture-Curing Urethane*	*Vinyl*
Use on Wood..............	EX	NR	EX	EX	EX	EX	NR	EX	NR
Use on Fresh Concrete.....	NR	EX	EX	EX	NR	NR	EX	G	EX
Use on Metal..............	EX	NR	EX	NR	EX	EX	G	G	EX
Min. Surf. Prep. for Metal	Class 3	X	Class 3	X	Class 1	Class 3	Class 3	Class 4	Class 4
Use as Clear..............	EX	NR	NR	NR	NR	EX	NR	EX	NR
Use in Aluminum Paint....	G	NR	G	NR	NR	EX		NR	G
Choice of Gloss............	Any	Flat	Any	Flat	Mod	Any	Any	High	Low
Service:									
Interior	EX	EX	EX	EX	NR	EX	EX	EX	NR
Normal Exposure	EX	G	EX	EX	EX	EX	EX	EX	EX
Marine Exposure	F	F	EX	F	F	G	EX	EX	EX
Corrosive Exposure ...	F	NR	EX	NR	NR	G	G	G	EX

Table 3. Comparison of Paint Binders
Film Properties

	Alkyd	*Cement*	*Epoxy*	*Latex*	*Oil*	*Phenolic*	*Rubber*	*Moisture-Curing Urethane*	*Vinyl*
Gloss Retention (Paint)	EX	[4]	P	[4]	P	EX	G	F	EX
Color, Initial	EX	G	G	EX	G	P	EX	EX	EX
Yellowing (Clear)	Slight	X	X	X	X	Cons	X	Mod	X
Fade Resistance (Paint)	EX	F	F	EX	G	G	G	F	EX
Hardness	G	EX	EX	G	P	EX	EX	EX	G
Adhesion	G	F	EX	G	EX	G	G	EX	F
Flexibility	G	P	EX	EX	EX	G	G	EX	EX
Resistance to:									
Abrasion	G	G	EX	G	P	EX	G	EX	EX
Water	F	F	G	F	F	EX	EX	EX	EX
Detergents	F	F	EX	G	F	EX	EX	EX	EX
Acid	F	P	G	G	P	EX	EX	EX	EX
Alkali	F	EX	EX	G	P	G	EX	EX	EX
Strong Solvents	P	EX	EX	G	P	G	P	EX	F
Heat	G	G	G	G	F	G		G	P
Moisture Permeability	Mod	V. High	Low	High	Mod	Low	Low	Low	Low

[4] Available as flat finish only.

Table 4. Comparison of Paint Binders
Principal Properties

	Alkyd	*Cement*	*Epoxy*	*Latex*	*Oil*	*Phenolic*	*Rubber*	*Moisture-Curing Urethane*	*Vinyl*
Ready for Use	Yes	No	No[3]	Yes	Yes	Yes	Yes	Yes	Yes
Brushability	A	A	A	+	+	A	A	A	−
Odor	+[1]	+	−	+	A	A	A	−	−
Cure—Normal Temp.	A	A	A	+	−	A	+	+	+
—Low Temp.	A	A	−	−	−	A	+	+	+
Film Build/Coat	A	+	+	A	+	A	A	+	−
Safety	A	+	−	+	A	A	A	−	−
Use on Wood	A	−	A	A	A	A	−	A	−
Use on Fresh Concrete	−	+	+	+	−	−	+	A	+
Use on Metal	+	−	+	−	+	+	A	A	+
Corrosive Service	A	−	+	−	−	A	A	A	+
Gloss—Choice	+	−	+	−	A	+	+	A	A
—Retention	+	X	−	X	−	+	A	A	+
Color—Initial	+	A	A	+	A	−	+	+	+
—Retention	+	−	A	+	A	−	A	−	+
Hardness	A	+	+	A	−	+	+	+	A
Adhesion	A	−	+	A	+	A	A	+	−
Flexibility	A	−	+	+	+	A	A	+	+
Resistance to:									
Abrasion	A	A	+	A	−	+	A	+	+
Water	A	A	A	A	A	+	+	+	+
Acid	A	−	A	A	−	+	+	+	+
Alkali	A	+	+	A	−	A	+	+	+
Strong Solvent	−	+	+	A	−	A	−	+	A
Heat	A	A	A	A	A	A	+	A	−
Moisture permeability	Mod	V. High	Low	High	Mod	Low	Low	Low	Low

+ = Among the best for this property
− = Among the poorest for this property
A = Average
X = Not applicable

[1] Odorless type

[3] Two component type

CHAPTER XV

AIR CONDITIONING

1. Theory of Air Conditioning

Air Conditioning is the simultaneous control, using a mechanical or absorption refrigeration system and related equipment, of the temperature, humidity, cleanliness, and distribution of the air within a structure. Heat always moves from a warm to a cooler surface or medium. Also, lowering the temperature of a refrigerant gas below its boiling point causes the refrigerant to condense and return to a liquid state. The process of condensation occurs in "free" air and can be observed when moisture from the air is deposited on the chilled surface of a glass filled with ice water. Stated simply, moisture in the air cools on contact with the surface of the cold glass and condenses. Every given quantity of air has a certain amount of moisture in it. At any fixed temperature, there is an upper limit to the amount of moisture a pound of dry air can hold. This point is known as the saturation point; when it is reached, moisture becomes visible as fog, mist, or water drops. For example, at 70° F the limit is 110 grains of moisture per pound of dry air. The addition of more moisture at this temperature would result in some form of condensation. At 40° F the limit is 36 grains of moisture per pound of dry air. Therefore, it can be seen that lowering the temperature of a pound of air lowers its ability to retain water vapor. If the pound of air in this example contained 24 grains of moisture instead of 110, its temperature could be lowered to 30° F before condensation would take place. Thus, the initial moisture content (between the extremes of saturated air and completely dry air) determines the extent of temperature drop necessary to effect condensation. These two variables -- temperature and moisture content -- can always be related to the relatively fixed number of grains of moisture air can hold at any one temperature before dew point is reached. This amount varies slightly with changes in altitude and atmospheric pressure but for practical purposes, the values given in Table 14-1 will serve to show the temperature-moisture relationship. For each temperature given in the Table, the maximum water vapor that can be supported without "dropping out" is given. It should be pointed out that there are approximately 7,000 grains to a pound of water.

TABLE 14-1

SPECIFIC HUMIDITIES AT VARIOUS TEMPERATURES
(At Standard Atmospheric Pressure)

Temperature (Degrees in Fahrenheit)	Grains of Moisture (Per Pound of Dry Air)
0	5.47
5	7.10
10	9.16
15	11.77
20	15.00
25	19.1
30	24.1
35	29.9
40	36.4
45	44.2
50	53.5
55	64.4
60	77.3
65	92.6
70	110.5
75	131.4
80	155.8
85	184.4
90	217.6
95	256.3
100	301.3
105	354.00
110	415.00
115	486.00
120	569.00

2. Definitions

An understanding of the amount of water vapor that can be held by a pound of air at any fixed temperature before condensation occurs provides a key to further analyze the complexity of terms used in air conditioning theory. For example, saturated air at 85° F can hold 184 grains of moisture per pound of dry air. If the temperature remains the same but the moisture content is reduced to one-half saturation capacity, or 92 grains, the percentage of humidity in relation to dry air will then be 50 percent. For all practical purposes, we can consider that the air at this temperature and moisture content has a 50 percent relative humidity. If, however, the temperature of this air is lowered from 85° to 64.9° F, 92 grains of moisture would then be as much water vapor as the air could hold, and the air would be at 100 percent relative humidity. Therefore, 64.9° F would be the dew point for this pound of air.

a. Dry Bulb Temperature. This is the temperature of air as read on an ordinary thermometer. A dry bulb reading does not take into account the heat in water vapor or latent heat. A dry bulb thermometer records what is generally termed sensible heat.

b. Wet Bulb Temperature. This is a measurement of the total heat of the air, including both heat of dry air and heat of moisture in air. A wet bulb thermometer is an ordinary thermometer with a saturated piece of cotton or fabric attached to its temperature-sensitive tip. In effect it measures the ability of air to absorb more moisture. If air is completely saturated (100 percent relative humidity), it can no longer absorb moisture. Therefore, moisture in the cloth sock on the end of the wet bulb thermometer cannot evaporate and the wet bulb reading will be the same as the dry bulb reading. If there is less moisture in the air, the water held by the cloth sock evaporates, the rate and extent of this evaporation being governed by the percentage of moisture in the surrounding air. Because evaporation of moisture involves a heat exchange (in this case between the thermometer and the water in the saturated cloth), the thermometer gives up heat to the process of vaporization. As a result, the wet bulb reading is lower than the dry bulb reading. The difference between these readings is often referred to as "wet bulb depression". For a given dry bulb temperature, the greater the depression, the dryer the air.

c. Specific Heat. Different substances and gases require varying amounts of heat to raise their temperatures. Water requires a great deal of heat energy to warm it, whereas, gasoline requires about half as much heat for any particular temperature rise. To establish a basis of comparison and to have a universal method of measuring the amount of heat needed to produce a fixed increase in temperature for various substances, the British Thermal Unit (BTU) was adapted. A BTU can be defined as the amount of heat required to raise the temperature of 1 pound of water 1 degree Fahrenheit. This amount of heat would be referred to as one BTU. Because water has been established as a fixed reference point in this system, the specific heat of water is 1.0. Other substances and gases have different specific heats, depending on how much more or less heat is required (in comparison with the amount required by water) to raise their temperature 1° F per pound. For example, the specific heat of gasoline is 0.50. In other words, it takes one-half as much heat to raise the temperature of 1 pound of gasoline 1° F as it does to raise the temperature of one pound of water 1° F. For general purposes, the specific heat of dry air can be considered to be 0.24. To find the amount of heat required to raise a substance or gas from one temperature to another, it is customary to multiply the number of pounds of substance or gas by the number of degrees the material is to be raised; then multiply this amount by the specific heat of the substance or gas. For example, to raise the temperature of 20 pounds of water 50 degrees, it will take 1,000 BTU (20 pounds x 50 degrees x 1); to raise the temperature of 20 pounds of dry air 50 degrees would require 240 BTU (20 pounds x 50 degrees x 0.24).

d. Latent Heat. This is the quantity of heat required to change a substance from one state to another without changing its temperature. Conversion of a gas or liquid from one state to another absorbs or releases an additional amount of heat without changing the temperature of the substance or gas involved. This "hidden" or latent amount of heat energy must be taken into account in air conditioning processes because liquids and gases are constantly moving from one state to another. With reference to air, the latent heat of vaporization is the amount of energy taken up by water vapor in the air to accomplish evaporation. Latent heat of condensation is the amount of heat energy released by water vapor as it returns to a liquid state. For example, when dry air mixed with water vapor is passed over cooling coils, latent heat of condensation is released by the water vapor and absorbed by the refrigerant in the coils. This is in addition to sensible heat being transferred to refrigerant coils. Therefore, whenever a change in state of air is involved, both kinds of heat must be taken into account.

e. Total Heat. Total heat is the combined amounts of sensible heat and latent heat. It is usually expressed as a single figure in BTU per pound of air.

f. Sensible Heat. Sensible heat is heat gained or lost by a body in passing from one temperature to another without a change in state. For example, if 1 pound of water is warmed from 35° to 45° F, 10 BTU of sensible heat have been added.

3. Sling Psychrometer

In actual practice, wet and dry bulb readings are taken simultaneously by means of two thermometers mounted on a common support and provided with a handle to allow the thermometer to be rotated rapidly through the air (See Figure 14-1). The rotation of the sling psychrometer should be continued until the reading on the wet bulb thermometer reaches its low point and stabilizes.

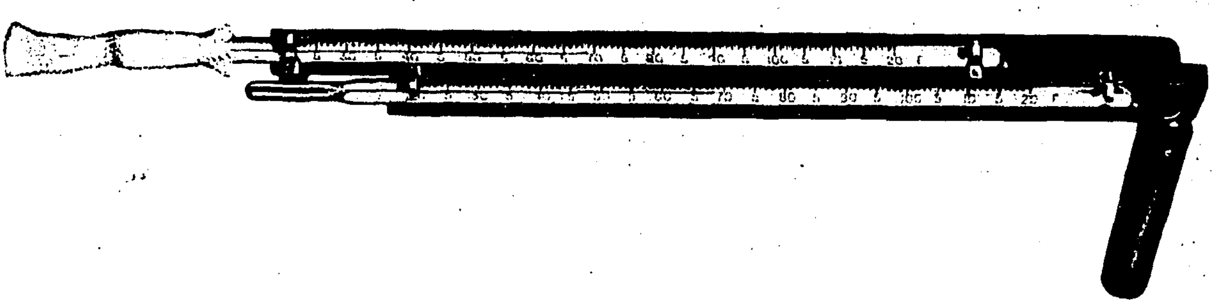
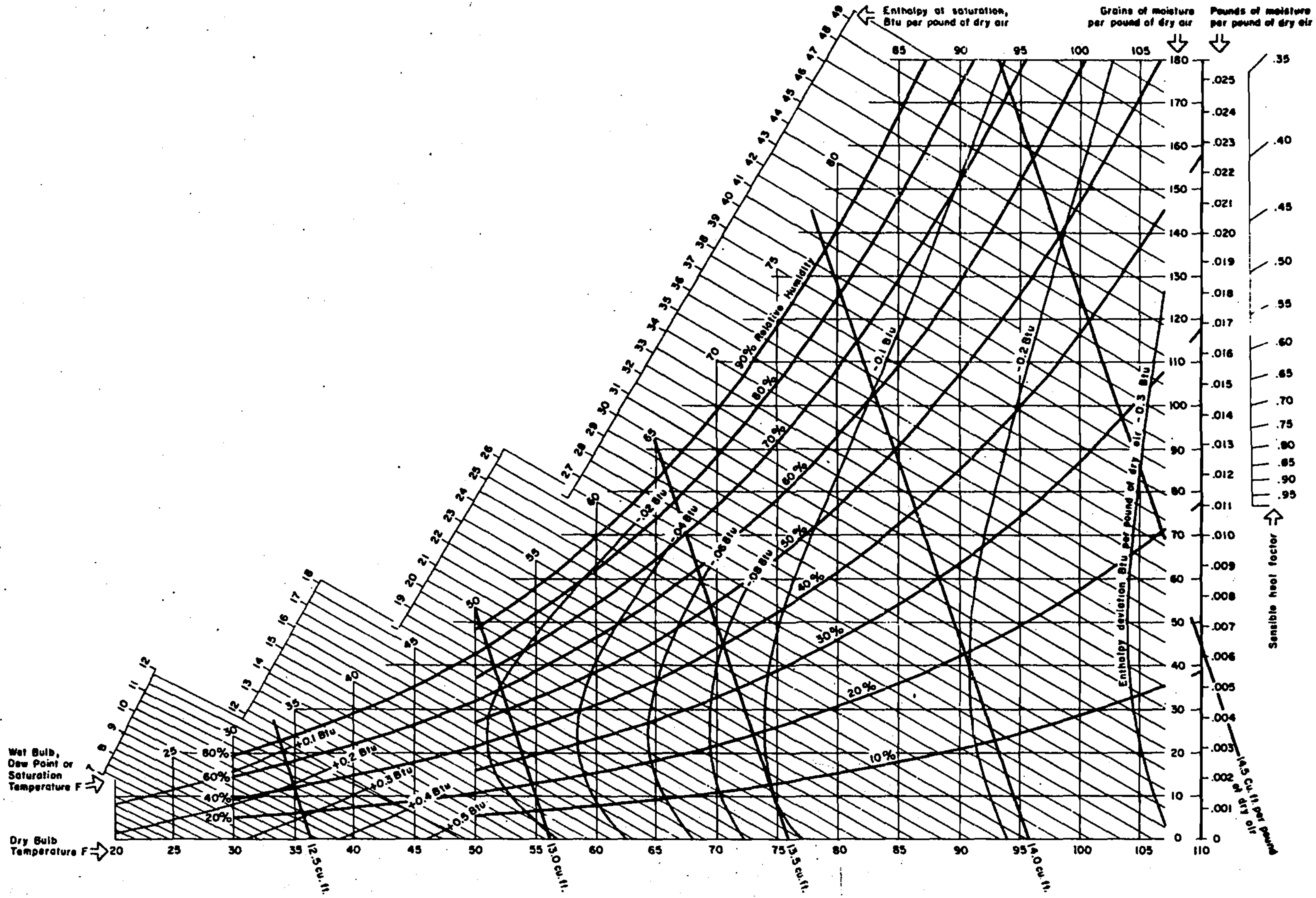


FIGURE 14-1 Sling Psychrometer

4. Psychrometric Chart

Emphasis has been placed on wet bulb temperature because it is an indirect and relatively easy method of determining the water vapor content of air. There is no practical method of isolating water vapor from dry air and counting the number of grains per pound. Wet bulb depression, however, is easily obtained and is a direct index of the amount of moisture present in air. The relationship between wet bulb depression and grains of water per pound of dry air can be plotted in chart form. From this, many facts about the properties of a particular quantity of air can be derived. With no more than wet and dry bulb readings obtained from a sling psychrometer, it is possible to use a "psychrometric chart" and determine relative humidity, dew point, moisture content in grains per pound of dry air, and other properties of the air in question. Figure 14-2 shows one of the more concise and simplified psychrometric charts. Use of it involves no more than knowing wet bulb and dry bulb thermometer readings. This chart is constructed for standard atmospheric pressure at sea level (29.92 inches of mercury) and will suffice for most normal installations. Similar charts are available for high altitude areas and situations where abnormally low surface pressures are encountered.

a. Use of the Chart. Assume that readings taken with a sling psychrometer were 85° F dry bulb and 70.5° wet bulb. Referring to Figure 14-1, dry bulb temperature (85°) is located at the bottom of the chart. Following the 85° line upward until it intersects the 70.5° F wet bulb line (slanting downward from left to right) the user marks this point. In this example, there is no wet bulb line for 70.5° F, so it is necessary to mark the point of intersection between the 70° and 71° wet bulb lines. The point of intersection having been marked, it will be found that, under these conditions, relative humidity is 50 percent, shown by the curved line also running through this point. Projecting a point horizontally to the left to the wet bulb scale will give the dew point of 64.4° F. The steep diagonal line running through the point of intersection indicates that 1 pound of air under these conditions will occupy 14 cubic feet. Projecting a point horizontally to the right shows there are 90 grains of water per pound of dry air. Total heat, found by following the wet bulb line upward to the left, is 34 BTU per pound of air, which is the heat represented by dry air plus latent heat present at this degree of partial saturation (50 percent relative humidity). If the sensible temperature of 85° F stayed the same but the relative humidity was 70 percent, total heat would be 39.5 BTU per pound of air. This indicates the importance of latent heat in water vapor.



Below 32°F, properties and enthalpy deviation lines are for ice

FIGURE 14-2 Psychrometric Chart for Standard Barometric Pressure

b. Practical Application. Most air conditioning systems are designed to produce 74 to 80 degrees dry bulb temperature and a relative humidity of from 45 to 50 percent in the space being conditioned. By use of the sling psychrometer and psychrometric chart, Inspectors can determine whether equipment is operating efficiently and meeting the specification conditions. Air that is too "wet" prevents evaporation from the skin, causing more discomfort than air that is too warm. For this reason obtaining relative humidity in an enclosed space should be the first step in estimating the performance of air conditioning equipment. Assuming that the system has been properly designed and installed, high humidities can be traced to efficiency losses in refrigeration components or to an increase in the volume of air (cubic feet per minute) delivered by the system fan or blower. Air leaving the evaporator must obviously be at lower than room temperature to effect any cooling. This temperature differential is usually between 15 and 20 degrees. The exact temperature difference is determined by the volume in cubic feet per minute of air blown into the area. For large fan deliveries, a small difference between room temperature and temperature of the air leaving the evaporator is required. Conversely, for lesser fan deliveries, a larger temperature difference is needed. Size and placement of cool air outlet grilles determine velocity of delivered air as well as its volume per minute. This is a design determination in which the objectives are to supply sufficient cool air to take care of the heat load and to keep air velocities down to the point where objectionable drafts and noises are prevented.

5. Cooling Requirements

Even though Inspectors need not be thoroughly versed in the intricate computations used for design of air conditioning equipment, some understanding of the methods employed will aid in pinpointing equipment faults. Prior to design of a system, an estimate of hourly heat load in BTU per hour is made. This estimate includes heat created by solar radiation, moisture infiltration, lights, power equipment, sunlight, latent and sensible heat given off by individuals occupying the area, and numerous other heat sources. Obviously, such an estimate cannot apply at all times throughout a 24-hour period during the cooling season. However, equipment is designed to operate efficiently under the combined effect of many heat producing agencies. As a result of these calculations, it is decided to install a system having so many "tons" of cooling capacity. One ton of refrigeration capacity is equal to the removal of 12,000 BTU per hour or 200 BTU per minute. This is equivalent to the cooling effect of melting one ton of ice in 24 hours. If an air conditioning installation in a small structure has a capacity of two tons, it can be theoretically regarded as being capable of removing 24,000 BTU from the interior of the structure each hour. Design data of this nature should be available to the Inspector and should be utilized in analyzing the performance of any air conditioning system.

6. Air Requirements

Proper distribution of cooled air is vital to satisfactory operation of an air conditioning unit. To calculate the volume in cubic feet per minute of air needed per ton of refrigerant capacity, the following factors must be known or established: Predetermined temperature difference between interior air (inside dry bulb design temperature) and temperature of air leaving cooling coils; and sensible heat load of the conditioned space. After volume of air delivery has been determined, the system can be checked for proper operation by measuring air velocity at coil faces, grilles, and in the interior of ducts. Any reduction in this air is being blocked by frost accumulation or dust on evaporator coils, improper operation of the blowers or blockage in ductwork causing loss of efficiency.

7. Measuring Air Velocities

Various instruments measure velocity of air flow at coil faces, grilles, and in the interior of ducts. Most common of these are the Pitot Tube (Figure 14-3), Anemometer (Figure 14-4) and direct-reading Velocity Meter (Figure 14-5).

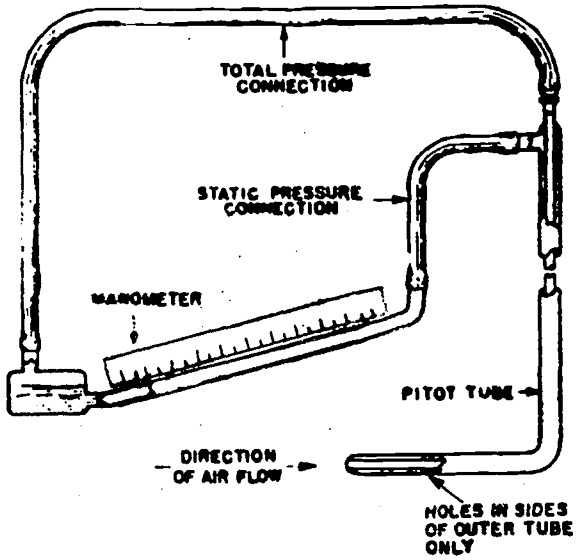


FIGURE 14-3

Pitot Tube to
Measure Velocity

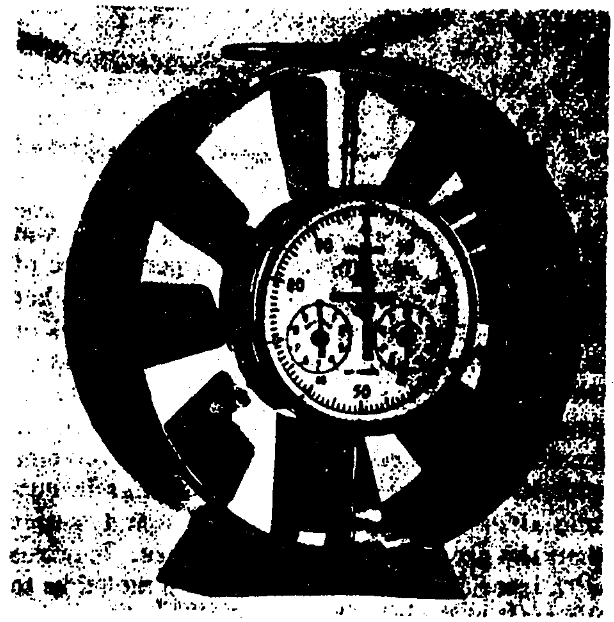


FIGURE 14-4

Anemometer Measuring Air
Delivery from Face of Grille

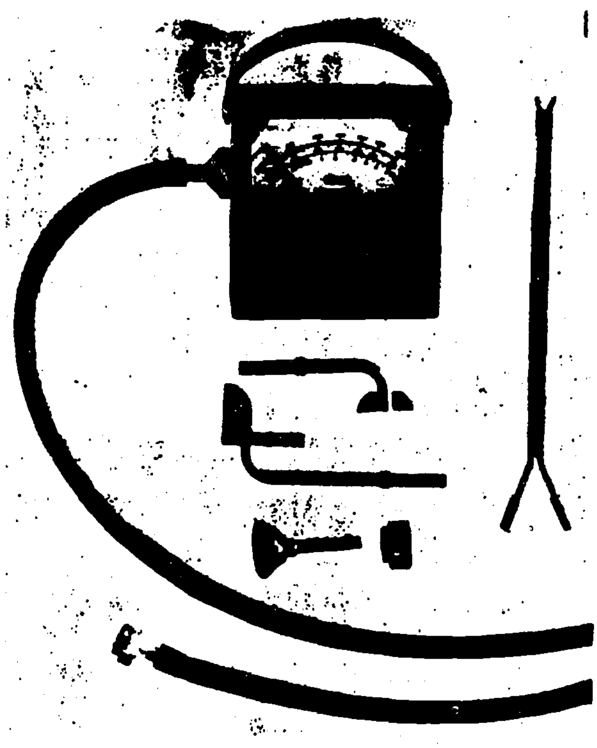


FIGURE 14-5

Direct-Reading Velocity
Meter

When an anemometer is used against a coil face, certain constants are applied to reduce readings. When an anemometer is used against the downstream face of a coil, the constant is 0.70; on the upstream face of the coil, the constant is 0.85. In the following formula, "C" represents this factor, which is used for converting velocity into cubic feet per minute.

CFM = C X average velocity x square feet of face area

8. Air Conditioning Systems

An assembly of air conditioning equipment can be considered a system when it contains equipment to cool, dehumidify, clean and distribute air to an area or space being conditioned. Air distribution is accomplished by fans or impellers moving air across evaporator coils and distributing air through ducts to outlets in the various rooms or spaces in a structure. In many systems, air is circulated and returned to the conditioning unit so that the same air undergoes a continuing cooling cycle. Each time the air passes over the cooling coils, its temperature is lowered and moisture is condensed on the evaporator coils. A number of factors, however, limit the extent of this recirculation. One is the necessity for removing smoke and odors, thereby causing a certain percentage of air to be exhausted from the area either through outlet grilles remote from the unit or through the natural process of exfiltration through cracks around windows and doors. Another limiting factor is that some fresh air must be introduced into the area to overcome staleness of air. Ventilation air brings in outside air which is usually warmer and wetter than the air being cycled in the area. It mixes with interior air and adds heat and moisture to the total cooling load.

9. Self-Contained Air Conditioners

The two general types of self-contained units are room coolers and self-contained floor units.

a. Room Coolers (Figure 14-6) also commonly called window units, usually have a capacity of 1/3 to 2 tons. Utilization of windows for installation of these units is not a necessity. They may be installed directly in outside walls (commonly called through the wall installation). The unit must have access to outside air for ventilation and exhaust and for the air-cooled condenser. In construction and operating principles, the room cooler is a small, simplified version of certain parts of a central system.

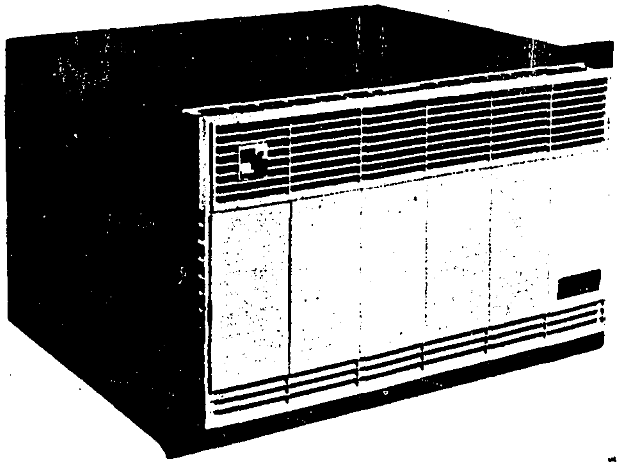


FIGURE 14-6 Room Cooler

As shown in Figure 14-7 and Figure 14-8, basic refrigeration components are present. Cooling of condenser coils is accomplished by air. Circulation of room air is accomplished by a fan blowing across evaporator coils. Moisture condensed from humid air by these coils is collected in a pan at the bottom of the unit, and usually drained toward the back of the unit where the condenser fan picks up drainage as droplets and mist and adds it to the air blast cooling the condenser. Most room coolers are equipped with thermostats, which maintain a fixed dry bulb temperature in an area within reasonable limits.

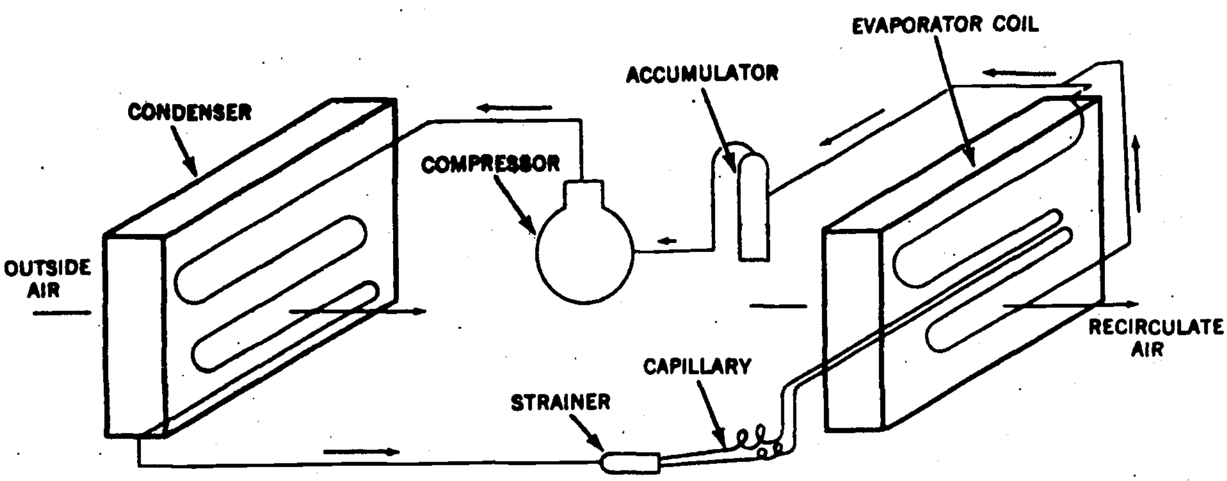


FIGURE 14-7 Refrigerant cycle of room cooler

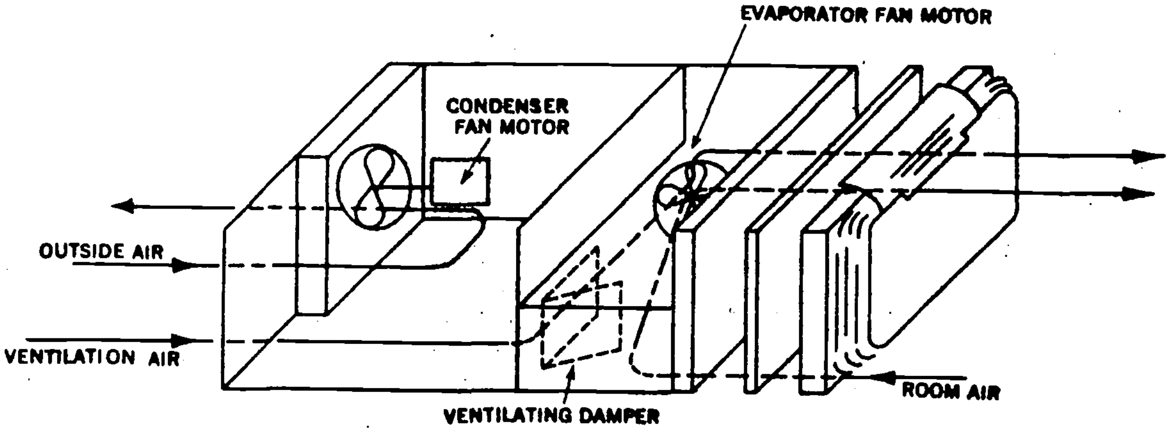


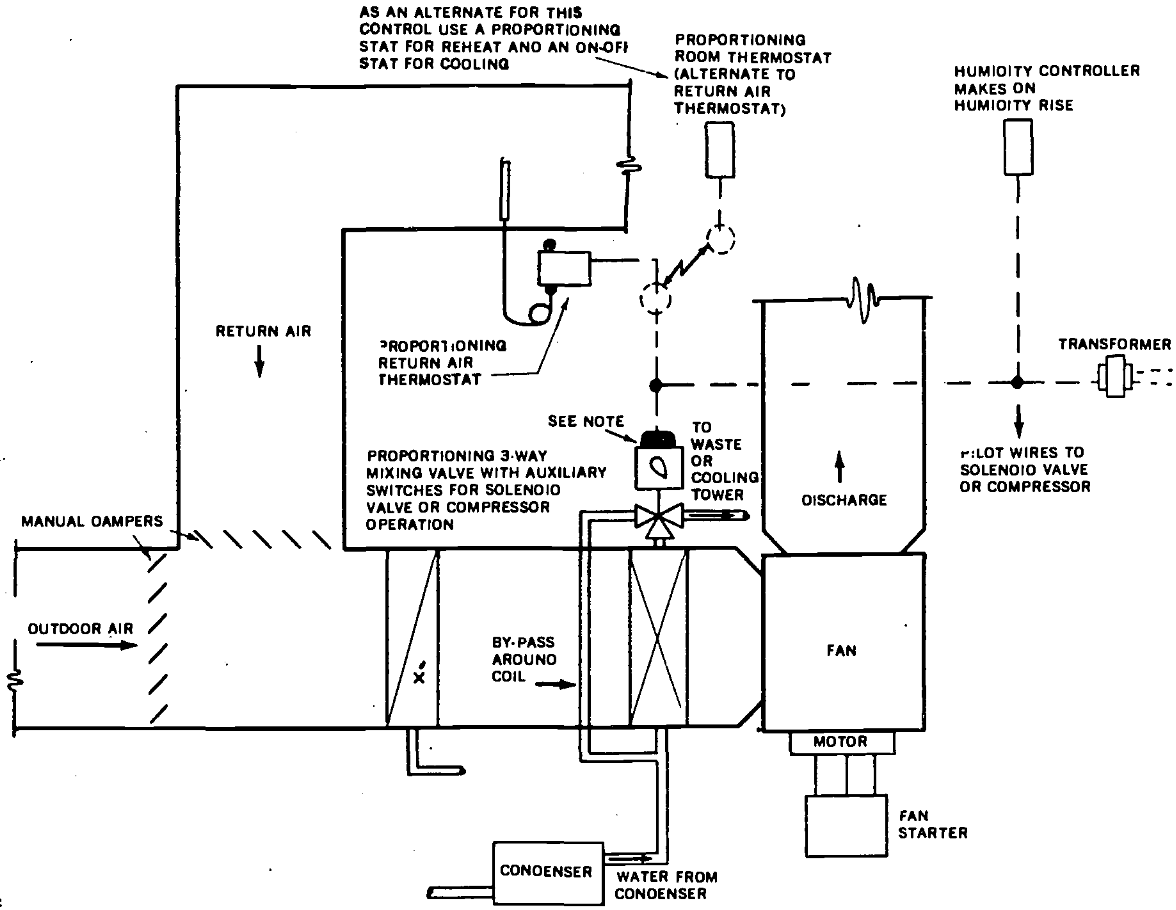
FIGURE 14-8 Air Handling Components of Room Cooler

b. Self-Contained Floor Units. These units range in size from 2 to 30 tons and are sometimes referred to as "Package Units". As in the case of room coolers, these larger units contain a complete system of refrigeration components. Air delivery is either produced directly from the unit or conveyed by ducts to the area being cooled.

10. Central Systems

Refrigeration from a central system is usually located in an equipment room designed for that use. Some central air conditioning installations are made in penthouses on roofs of larger buildings. It is beyond the scope of this chapter to discuss the variety of ways in which central system equipment can be combined and arranged. In a sense, every major installation of this kind is "custom made" to fit equipment space for machinery and air conditioning requirements of the building. Figure 14-9 shows a simple schematic of the most common type of central system arrangement. In equipment of this kind, controls are provided to maintain design conditions in conditioned areas. An automatic bypass system may be used where close humidity control is not required. A re-heat system is used when a bypass system will not provide sufficient dehumidification during a period of low outside dry bulb temperature and high outside wet bulb temperature.

Figures 14-10 through 14-12 show schematics of other possible central system arrangements.



NOTE:
IF REHEAT SYSTEM IS OTHER THAN SHOWN, THE MOTOR WILL NOT OPERATE A THREE-WAY VALVE, BUT WILL OPERATE CONTROLLING MECHANISM AS LISTED.

REHEAT MEDIUM:
1. HOT GAS
2. STEAM
3. ELECTRICITY

CONTROLLED MECHANISM
MOTOR FOR FACE AND BY-PASS DAMPERS AROUND COIL
PROPORTIONING SINGLE SEATED VALVE IN STEAM SUPPLY TO COIL
PROPORTIONING PROGRAM SWITCH USED TO SEQUENCE ELECTRIC STRIP HEATER OPERATION

FIGURE 14-9 Arrangement of Equipment for Year-Round Air Supply System

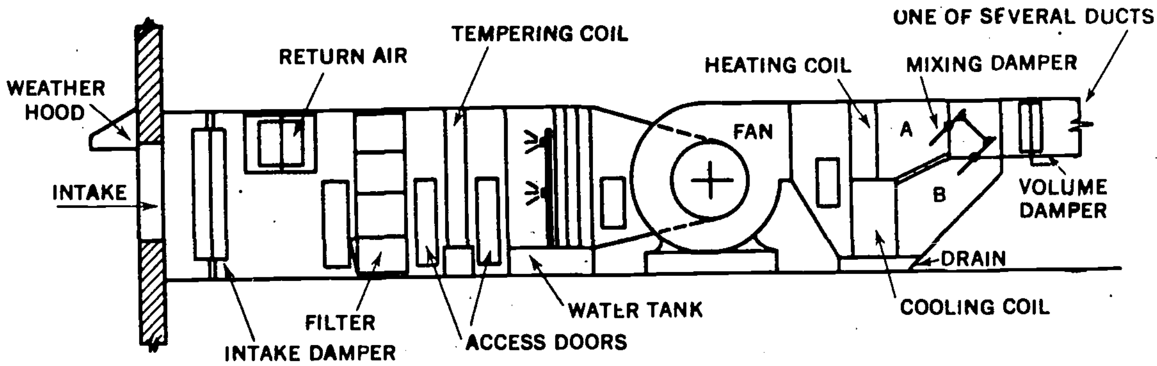


FIGURE 14-10
Alternate Arrangement of Equipment for Controlling Air Condition in Central Air Supply System

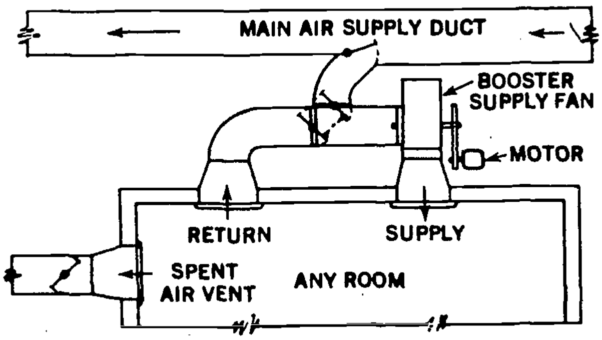


FIGURE 14-11
Arrangement for Individual Room Temperature Control

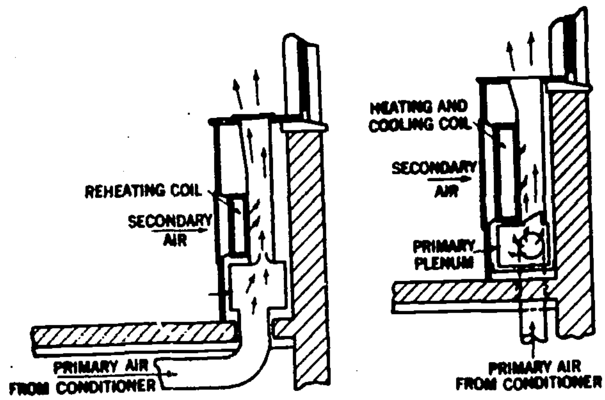


FIGURE 14-12
Low-Velocity Duct System

11. Chilled Water Systems

Water chillers are used in air conditioning for large tonnage capacities and for central refrigeration plants serving a number of zones, each with its individual air-cooling and air-circulating units. An example is a large hospital with wings off a corridor. Air conditioning may be necessary in operating rooms, treatment suites, and possibly some recovery wards. Chilled water-producing and water-circulating equipment is located in a mechanical equipment room. Possibilities of leakage causing high replacement costs for refrigerant, when long mains with many joints are necessary between condensing equipment and conditioning units, may make it desirable to provide water-cooling equipment close to condensing units and to circulate chilled water to remote air-cooling coils. Chilled water is circulated to various room-located coils by a pump, and control of temperature of air leaving each coil may be accomplished by a thermostat that controls a water valve or stops and starts each cooling coil fan motor.

12. Heat Pump

a. <u>Description</u>. A heat pump is a device for removing heat from one place and putting it into another. A domestic refrigerator is a heat pump in that it removes heat from inside a box and releases it to the outside. The only difference between a refrigerator and residential or commercial heat pump is that the latter can reverse its system.

The heat pump is one of the most modern means of heating and cooling. Using no fuel, the electric heat pump automatically heats or cools as determined by outside temperature. The air-type unit works on the principle of removing heat from the atmosphere. No matter how cold the weather, there is always some heat which can be extracted and pumped indoors to provide warmth. To cool during heat months, this cycle is merely reversed with the unit removing heat from the area to be cooled and exhausting it outside. The heat pump is designed to control the moisture in the air and remove dust and pollen. Cool air provided during hot weather enters with uncomfortable moisture removed. In winter, when the natural atmosphere is desirable, air is not dried out when pumped indoors.

b. Operation. The heat pump is simple in operation (Figure 14-13). In summer, the evaporator is cooling and the condenser outside is giving off heat the evaporator picked up. In winter, the condenser outside is picking up heat from the outside air because its temperature is lower than that of the outside air (until it reaches the balance point). This heat is then sent to the evaporator by the compressor and is given off into the conditioned space. This operation is accomplished by a reversing valve. The compressor always pumps in one direction, so the reversing valve changes the hot gas direction from the condenser to the evaporator as indicated by the setting on the thermostat. The setting of the thermostat assures a constant temperature through automatic change from heating to cooling anytime that outside conditions warrant. Heat pumps are made not only for small homes but large homes and commercial buildings as well. The heat pump does not require an equipment room and its minor noise is discharged into the atmosphere. The remote heat pump has only a blower and evaporator, which can be installed under the floor, in an attic or other out of the way location, depending on the application and its requirements. Supplemental heat can be added into the duct and set to come on by a second stage of the thermostat, an outside thermostat, or both, depending on design of the system.

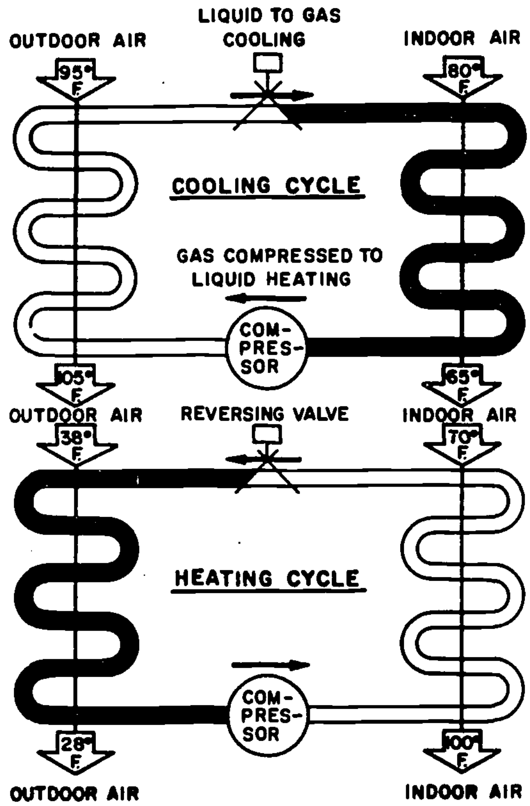


FIGURE 14-13 Simplified Operation of Heat Pump

13. Grilles, Registers and Ceiling Defusers

Uniform distribution of conditioned air is effected through the location of outlets to suit area requirements. Grilles, registers and ceiling diffusers are selected by design engineers and architects to properly regulate air velocity, volume and direction for specific requirements. Grilles with directional blades are commonly used in walls as air outlets in both residential and commercial applications. Registers are usually constructed with fixed vanes or equipped with a blade damper. They are primarily used for residential and small-room inlet air control where the outlet distribution is not critical, and low cost is important (Figure 14-14). Ceiling diffusers (Figure 14-15) are constructed in numerous designs and shapes to fit exacting requirements of uniform air distribution

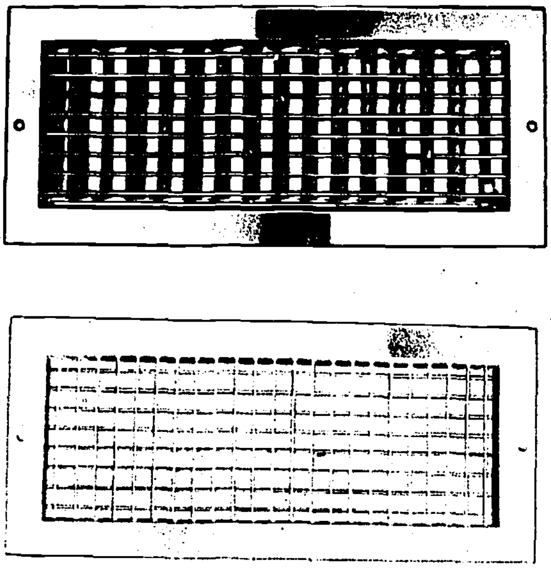


FIGURE 14-14
Typical Supply and Return Grilles

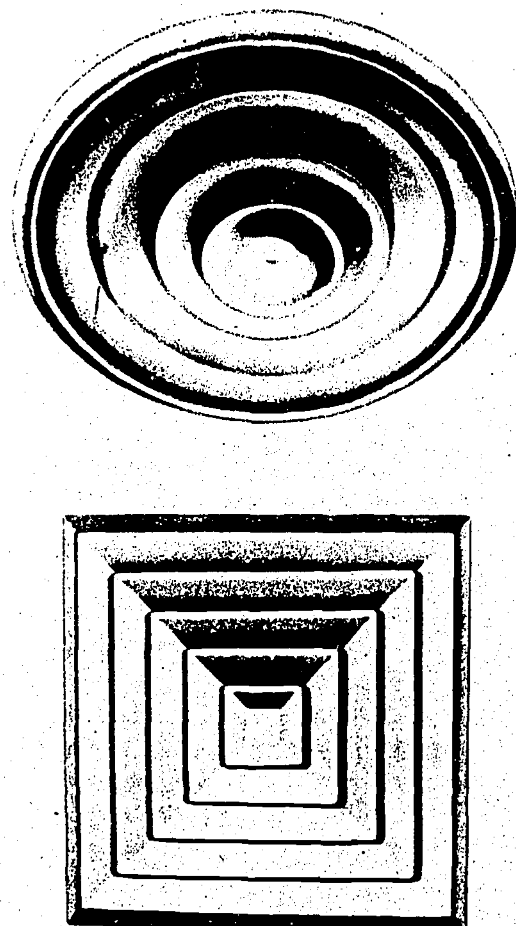


FIGURE 14-15
Typical Circular and
Rectangular Ceiling Diffusers

TABLE 14-2

Service Chart for Condensing Unit Operation by Suction Pressure Control with Thermostatic Expansion (Te) Valve, High-Side (Hs) Float Valve, or Low-Side (Ls) Float Valve

Symptoms	Type of refrigerant valve	Possible causes
Condensing unit will not run		
Evaporator all frosted (or fully active) at normal idle cycle temperature		
Suction line warm. Suction and discharge pressures normal for idle cycle.	**All types**	**Evaporator cold enough but air circulation in refrigerator blocked; blower fan stopped.**
Pressure control open.		**Control not set low enough.**
Evaporator warm or above normal idle temperature		
Suction line warm. Suction pressure high. Discharge pressure normal for idle cycle. Pressure control closed.	**All types**	**Power line to building dead; storm or breakdown. Main or branch line fuses blown; short circuit, ground, overload (struck or tight compressor or motor or tight belt) fuse loose in clips, fuses too small. Open in main or branch electric circuit; broken wire, bad fitting, loose connection. Belt broken; motor running, compressor idle**

TABLE 14-2 (Continued)

Symptoms	Type of refrigerant valve	Possible causes
Suction line warm. Suction pressure low. Discharge pressure normal for idle cycle. Pressure control open.	All types	Strainer, dehydrator, line valve, or fitting stopped up; liquid line kinked. Space around refrigerator too cold; suction pressure does not rise to cut-in setting; (condensing unit in normal temperature room).
	TE valve	Power element of expansion valve dead, that is, out of charge.
	HS float LS float	Float needle stuck on seat.
	HS float	Float ball to small, too heavy, or leaking (has liquid refrigerant in it). Float assembly out-of-level; ball too low. Float assembly gas-bound; air in float body or float placed in too warm location.
Suction line warm. Suction and discharge pressures low. Pressure control open.	All types	System about out of refrigerant.
Condensing unit short cycles		
Evaporator entirely or not fully frosted (or active)		
Suction line warm. Suction pressure normal to high. Discharge pressure low.	All types	Pressure control defective; fluttering contacts. Loose connection in electrical circuit. Pressure control differential too narrow. Automatic-reset overload device on motor short-cycles: Belt too tight Low voltage Motor defective or type having too low torque. Discharge valves in compressor leaking back.
	TE valve HS float	System low on charge. Refrigerant valve sticky in action due to dirt, gum, wax, ice, and the like, in valve. Partial stoppage of liquid line strainer, dehydrator, line or receiver valve or fitting; liquid line kinked.
	TE valve	Power element partially out of charge. Expansion valve loading spring broken. Ice in body bellows or diaphragm, holding needle in partially closed position.

TABLE 14-2 (Continued)

Symptoms	Type of refrigerant valve	Possible causes
		Valve body in too cold location; takes control from bulb. Valve adjusted for too much superheat. Bulb located where not readily affected by coil outlet temperature and superheat change. Excessive pressure drop across evaporator. Excessive pressure drop in liquid line; line too small or too long. Evaporator too far above condensing unit.
	HS float	System low on charge. Float gas-bound; air in float body or float placed in too warm position. Float body out-of-level; ball too low. Float ball too small or too heavy or leaking (has liquid refrigerant in it). Float needle sticking on seat or mechanism sticky; not opening and closing freely. Excessive pressure drop in liquid line. Evaporator too far above condensing unit.
	LS float	Needle sticking in closed position, allowing only slight amount of refrigerant in. Evaporator and float chamber oil-logged. (Leaky needle or defective oil return device.)
Suction line warm. Suction pressure normal to high. Discharge pressure high.	All types	High pressure cutout short cycles. Air-cooled condensing unit: Condenser dirty; dust, lint, and the like. Air to or from condenser blocked or restricted. Air from condenser recirculated through condenser. Air to condenser too warm. Cutout defective. Water-cooled condensing unit: Insufficient water to condenser (restricted). Water pressure too low. Supply water to warm. Air in system. Condenser fouled with scale, dirt, and the like. Cutout defective.

TABLE 14-2 (Continued)

Symptoms	Type of refrigerant valve	Possible causes
		Automatic-reset overload device on motor cycling: Suction and/or discharge pressure too high. Air temperatures around motor too high.
Evaporator all frosted (or fully active)		
Suction line cool to cold. Suction and discharge pressures low.	All types	Fan motor on evaporator (blower type) running too slowly; fan slipping on motor shaft. Evaporator iced up between fins, area reduced. Condensing unit capacity too great for evaporator and/or load.
Condensing unit runs too long or continuously		
Evaporator entirely or partially defrosted (or not fully active)		
Suction line warm. Suction pressure high. Discharge pressure low.	All types	Compressor inefficient, leaking suction and/or discharge valves, worn rings, excessive clearance volume, and the like. Belt slipping. Low voltage to motor.
Suction line warm. Suction and discharge pressures high.	All types	Condensing unit overloaded; doors being left open, hot room, leaking door gaskets, abnormal food storage. Air to air-cooled condenser restricted or recirculated or air supply too warm; condenser dirty. Water to water-cooled condenser restricted or to warm; condenser dirty; water valve stopped or out of adjustment. Condenser and/or fan too small.
Evaporator possibly all frosted (or fully active) but not cold enough.		
Suction line cool. Suction pressure high. Discharge pressure low.	TE valve	Expansion valve set for too little heat. Expansion valve bulb in too warm place; or bulb affected by warm air. Expansion valve sticking in open position. Folds of body bellows of expansion valve frozen together holding valve in open position. Expansion valve defective, to large or wrong type.

TABLE 14-2 (Continued)

Symptoms	Type of refrigerant valve	Possible causes
	HS float	System overcharged with refrigerant. Float needle leaking at seat. Float chamber not level; ball too high.
	LS float	System low on refrigerant charge. Restriction in liquid line, strainer, dehydrator, line valves.
Suction line cool. Suction pressure low. Discharge pressure normal to low.	All types	Capacity of condensing unit too great for load and/or evaporator capacity. Finned type evaporator iced up; area reduced, circulation blocked.

TABLE 14-3 Service Chart for Condensing Unit Operation by Temperature Control with Automatic Expansion (Ae) Valve, Thermostatic Expansion (Te) Valve High-Side (Hs) Float Valve, Low-Side (Ls) Float Valve, Capillary Tube

Symptoms	Type of refrigerant valve	Possible causes
Condensing unit will not run		
Evaporator all frosted (or fully active) at normal idle temperature		
Suction line warm. Suction and discharge pressures normal for idle cycle.	All types	Temperature control open; evaporator cold enough, but air circulation in refrigerator blocked; fan stopped. Temperature control open; not set low enough.
Evaporator warm or above normal idle cycle temperature		
Suction line warm. Suction pressure high. Discharge pressure normal for idle cycle.	All types	Power line to building dead; storm or breakdown. Main or branch line fuses blown; short circuit, ground overload (struck or tight compressor or motor or tight belt) fuse loose in clips, fuses too small. Open in main or branch circuit; broken wire, bad fitting, loose connection. Temperature control contacts burned and open. Belt broken; motor running, compressor idle. Charge in power element of temperature control partially or entirely lost. Space around refrigerator too cold; not enough load on refrigerator to require condensing unit operation.
Suction line warm. Suction pressure high. Discharge pressure low even for idle cycle.	All types	Space around condensing unit colder than in refrigerator; charge condenses in power element in control instead of bulb.

TABLE 14-3 (Continued)

Symptoms	Type of refrigerant valve	Possible causes
Condensing unit short-cycles		
Evaporator defrosted or not entirely frosted (not fully active)		
Suction line warm. Suction pressure normal to high. Discharge pressure normal.	All types	Temperature control defective; fluttering contacts. Loose connection in electrical circuit. Automatic-reset overload device on motor short cycling: Stuck or tight compressor or motor Belt too tight Low voltage Motor defective or too low starting or running torque. Temperature control differential too narrow.
	All types	High pressure cut-out short cycles. Water-cooled condensing unit: Cutout defective Insufficient water to condenser (restricted). Water pressure too low Supply water too warm Air in system Condenser fouled with scale, dirt, and the like. Air-cooled condensing unit: Condenser dirty; lint, dust, and the like. Air to or from condenser blocked or restricted. Air from condenser circulated through condenser. Air to condenser too warm. Automatic-reset overload device on motor cycling: Suction and/or discharge pressures too high. Air temperatures around motor too high.
Condensing unit runs too long or continuously		
Evaporator does not frost (or not fully active)		
Suction line warm. Suction and discharge pressures low.	All types	System about out of refrigerant. Strainer dehydrator, line, or receiver valve, or fitting partially or entirely stopped. Liquid line kinked. Stoppage in refrigerant valve—dirt, ice, wax, gum, or other foreign matter. Excessive pressure drop in liquid line because tubing is too small or too long. Evaporator too far above condensing unit. Excessive pressure drop across evaporator.

TABLE 14-3 (Continued)

Symptoms	Type of refrigerant valve	Possible causes
	AE valve or TE valve only	Expansion valve loading spring broken. Ice in body of bellows or diaphragm, holding valve needle almost closed.
	AE valve only	Expansion valve adjusted for too low operating pressure.
	TE valve only	Expansion valve adjusted for too much superheat. Expansion valve power element partially or entirely out of charge. Needle sticking in closed position because of mechanical tightness or needle sticking on seat.
	HS float	Float ball set too high. Float needle sticking in closed position because of mechanical tightness or needle sticking on seat. Float body gas-bound or air in float chamber. Float located in two warm a place (gas-bound).
	LS float only	Evaporator and float chamber oil-logged (leaky needle or defective oil-return device).
	Capillary tube only	Capillary tube kinked or partially or entirely stopped by dirt, wax, gum, ice, insulation, scale, or the like. Capillary tube too long or too small. Discharge pressure too low. Room temperature too low (air-cooled) water valve open too wide (water-cooled).
Suction line warm. Suction pressure high. Discharge pressure low.	All types	Compressor inefficient; leaking suction and/or discharge valves, worn rings, excessive clearance volume.
Evaporator possibly all frosted (or fully active) but not cold enough.		
Suction line cool to cold. Suction pressure high. Discharge pressure high.	All types	Condensing unit overloaded; too much product, service, or heat leakage load. Condensing unit under-capacity; belt slipping, low voltage. Air-cooled condenser dirty or air-flow obstructed and/or recirculated; supply air too warm. Water-cooled condenser dirty or scaled; not enough or too warm cooling water available. Air in system

TABLE 14-3 (Continued)

Symptoms	Type of refrigerant valve	Possible causes
	HS float	System overcharged with refrigerant.
	LS float	Low on charge of refrigerant.
Suction line cool to cold. Suction pressure low. Discharge pressure normal to low.	All types	Temperature control contacts burned, and sticking; power element lost charge. Temperature control set too low. Capacity of condensing unit too great for load and/or evaporator capacity. Fan on evaporator (blower-type) not running. (Fan slipping on shaft or motor not running). Finned-tube evaporator iced up; area reduced and circulation blocked.

TABLE 14-4 Troubleshooting Chart for Sealed Units

Complaint	Cause	Diagnosis
Compressor runs continuously; good refrigeration effect.	Air over condenser restricted.	
Compressor runs continuously; unit is too cold.	Thermostatic switch contacts badly burned. Thermostatic switch bulb loose. Thermostatic switch improperly adjusted.	
Compressor runs continuously; little refrigeration effect.	Extremely dirty condenser. No air circulating over condenser. Ambient temperature too high. Load too great.	
Compressor runs continuously; no refrigeration.	A restriction that prevents refrigerant from entering evaporator. A restriction is usually indicated by a slight refrigeration effect at point of restriction. Wattage runs from normal to high. Compressor not pumping. This would be indicated by a cool discharge line and a hot compressor housing. Wattage is generally low. Short of refrigerant.	
Compressor short cycles, poor refrigeration effect.	Loose electrical connections. Defective thermostatic switch.	

TABLE 14-4 (Continued)

Complaint	Cause	Diagnosis
	Defective motor starter.	
	Air restritcion at evaporator.	
Compressor short cycles, no refrigeration.	Dirty condenser.	
	Ambient temperature too high.	
	Defective wiring.	
	Thermostatic switch operating erratically.	
	Relay erratic.	
Compressor runs too frequently.	Poor air circulation around condenser or too high ambient temperature.	
	Load too great.	
	Worn compressor. Generally accompanied by rattles or knocks.	
Compressor does not run.	Motor is not operating.	Starting and running of motor should be checked with an ammeter, connecting ammeter in circuit in series with terminals. First, hook ammeter in series with starting and running winding; second, place ammeter in series with running winding and ground; third, place ammeter in series with starting winding and ground. If current exceeds manufacturer's specifications, it is an indication of a grounded winding; no reading indicates an open circuit. After making certain that wiring is complete, connect a three-wire cord to current outlet. If motor starts, remove wire on starting circuit. Fact that motor starts indicates that trouble is in relay or thermostatic switch. Then check thermostatic switch. Open switch and see if switch contact points are closed. If they are closed, remove and check relay. There are two general types of relays; hot-wire relay and magnetic relay. Either

TABLE 14-4 (Continued)

Complaint	Cause	Diagnosis
		type should be replaced if out of order.
Compressor will not run. (Assume that thermostatic switch, motor starter and relay, and electric wiring and current supply are in good conditon, and operating normally.)	If cabinet has been moved, some oil may be on top of piston.	
	Compressor may be stuck, or some parts may be broken.	
	Connections may be broken on inside of unit, or motor winding may be open.	
Compressor is unusually hot.	Condenser is dirty, or there is a lack of air circulation.	
	Unusually heavy service or load.	
	Low voltage.	
	Shortage of oil.	
No refrigeration after starting up after a long shutdown or on delivery.	Generally, during a long shutdown, an amount of liquid refrigerant will get into crankcase of compressor. When this happens compressor operation will cause no noticeable refrigeration effect until all liquid refrigerant has evaporated from crankcase.	
Compressor is noisy.	Mountings have become worn or deteriorated.	
	Walls against which unit is placed may be of an extremely hard surface and may resound and amplify	

TABLE 14-4 (Continued)

Complaint	Cause	Diagnosis
	slight noise from compressor into room.	
	Shortage of oil and/or refrigerant.	
	Sealed unit mechanism has become worn.	
After each defrosting there is a long on-cycle before refrigeration is again normal.	Slight shortage of refrigerant.	
	Condenser is dirty.	
	Thermostatic switch bulb is loose.	
	Restriction between receiver or condenser and/or evaporator.	
	Compressor is not pumping to full capacity. This can be checked by amount of heat being sent to condenser.	

CHAPTER XVI

FLOOR FINISHES AND COVERINGS

Floor finishes and coverings are many and varied. A few of the more common are:

1. Concrete
2. Concrete Topping
3. Terrazzo
4. Resilient Floors over Concrete
5. Floor Covering Materials

Concrete floor with a monolithic finish is probably the most economical type of floor finish. However, it does have its disadvantages -- it is difficult to maintain as it absorbs, stains and dusts. Once painted, then it must be painted on a periodic basis.

Concrete Topping is usually applied immediately after the sub-floor is placed. The surface of the sub-floor should be left rough and with exposed aggregates to assure a bond with the topping. Topping is either purchased as a special mix, or mixed on the job site. Many manufacturers require special floor treatment such as bakeries, to assure that they have a smooth level surface to move their products over prior to the baking process. Others require acid or abrasive resistant surfaces. Topping may vary from 3/4 to 1 inch thick, depending upon the material and the manufacturer's recommendation.

Terrazzo floors are constructed by applying a mixture of marble chips or granules, portland cement (which is frequently used) and water, laid on an existing concrete or wood floor specially prepared for this purpose. Terrazzo topping usually varies from 1/2 to 3/4 inch thick. Several methods of installation are employed.

Terrazzo Bonded to Concrete. When placing terrazzo on a concrete floor it is necessary to bond it completely. This is accomplished by being sure the surface is cleaned and moistened, then placing a layer of underbed approximately 1 1/4 to 1 1/2 inches thick using 1 part portland cement, 4 parts sand, by volume, and enough water to produce a stiff mortar mix which is spread uniformly over the surface. At this point, brass or other metal strips are inserted into the plastic mix producing the required design such as squares or whatever is specified.

Relative humidity meter test consists of placing a relative humidity meter on a concrete surface under a polyethylene sheet, sealed at the edges with adhesive and tape. This test should be used whenever moisture sensitive resilient flooring is to be installed. On the thickest slabs tests should be run for 72 hours; on thin slabs 4 hours. In order to minimize temperature variations, the meter should be shielded from direct exposure to sunlight.

It is desirable to have the relative humidity down to or below 80% before installation of linoleum vinyl sheet floor covering or whenever a water soluble adhesive is used.

Floor Covering Materials. These are many and varied. Some of the most common used are as follows:

TYPE	BASIC COMPONENTS
Vinyl Sheet Flooring	Vinyl Resins, Asbestos Fibre or Rag Fibre Back
Homogeneous Vinyl Tile	Vinyl Resins
Vinyl Asbestos Tile	Vinyl Resins and Asbestos Fibers
Cork Tile with Vinyl Coating	Raw Cork, Vinyl Resins
Cork Tile	Raw Cork Resins
Rubber Tile	Rubber Compounds
Asphalt Tile	Resin, Asphaltic Compounds and Asbestos Fibers
Linoleum	Cork/Wood Flour and Oleoresins with Burlap Back

The selection of floor coverings are based upon many factors; among them being:

Architectural Effect
Traffic Requirements
Location and Moisture Conditions
Exposure to Sunlight
Economic Conditions

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Traffic Requirements
Location and Moisture Conditions
Exposure to Sunlight
Economic Conditions

The floor covering industry has engineered standards covering all possible situations with recommended solutions. They also provide an array of colors and patterns to satisfy most any architectural situation. The samples are available to all customers and should be provided the inspector prior to start of work.

CHAPTER XVII

SUSPENDED CEILINGS AND ACOUSTICAL TILE

Suspended ceilings and acoustical tile are manufactured by many firms in the United States. Each has, to a great extent, its own particular feature that supposedly sets it aside and apart from the others. Most all ceiling and tile products have some things in common and are even interchangeable to some extent. The specifications will usually specify a particular ceiling system and a specific tile with a statement to the effect that the manufacturer's instructions will be followed in the installation of the product. Failure to follow the manufacturer's instructions will probably void any guarantees or warrantees that are normally given with the system when purchased. Therefore, we can only discuss types of ceilings for specific conditions and types of tiles to satsify specific conditions.

Suspended ceilings are selected by Architect/Engineers on the basis of appearance, durability, ease of installation and maintenance, fire resistance and ability to accept the lighting, ducting and utility spaces and equipment usually installed above suspended ceilings. Some ceilings are designed to accept linear heating and air conditioning, others for grilles and diffusers. Almost all suspended ceiling manufacturers can supply an adequate system to satisfy most conditions; even though it may not be a standard item with their particular product. Then it becomes a matter of economics and whether or not it is economically feasible to adjust their product or change a manufacturing technique to satisfy a condition when other manufacturers already incorporate the features required by the specifications.

The more common systems of suspended ceilings consist of T-Bars, Cross Bars, end channels, clips, Z-Bars and splines in combinations to suit a particular ceiling tile or provide spacing of lighting, utilities or access to the space above the ceiling for servicing the utilities usually run in the space provided by the suspended ceiling. Because it is not possible to show or discuss the products of all suspended ceiling and tile manufacturers, only a few of the common types have been selected. Although the systems shown may vary slightly between manufacturers, most can provide them in one form or another.

Access tile or "Z" system uses a heavy "T" or "Z" bar construction with connecting cross bars which act as parallel splines (see Fig 16-1). This eliminates the requirement for supporting channels. This provides accessibility to wiring and duct work above the suspended ceiling. Tiles are factory-kerfed and ship-lapped to lift out of the suspension system yet hide the supporting members. Tiles are normally 12 x 24 inches.

Access tile or "T" system is a mechanical system with a concealed grid (see Fig 16-2). Tees are placed 24 inches on center, wire hangers not over 7 feet on center. Where fixtures, diffusers, etc., are carried on the suspension system, hanger wires must be placed on all four corners of the equipment. Where cross runners are usually 6 to 8 feet apart on center, or where recessed light fixtures occur, cross runners must be placed as close as possible to the end of the fixtures. Normally 12 x 24 inch tile is supplied.

H and T concealed system (see Fig 16-3) is capable of accommodating tile in ranges of 12 x 12 x 12 inches, 24 x 24 x 24 inches or 48 x 48 x 48 inches.

Z concealed system (see Fig 16-4) utilizes a T spline and kerfed tile.

T exposed (see Fig 16-5) is a simple runner and cross T upon which the tile is placed. This is a very common and economical type system.

Adhesive Tile should be applied only to dry level surfaces. Installation procedure is to apply four walnut size spots of adhesive with a trowel or putty knife to each square foot of tile. Adhesive and tile should be applied in areas of approximately 70° F. Tile should be pressed into place 1/2 to 1 inch from final location and then slid into and out of place at least once before final set. To level tile, remove and adjust size of adhesive daub. High humidity areas should be avoided as moisture tends to weaken adhesive. New concrete requires approximately 6 months drying time before setting tile. Plaster requires about 4 to 5 weeks drying time. (Fig 16-6)

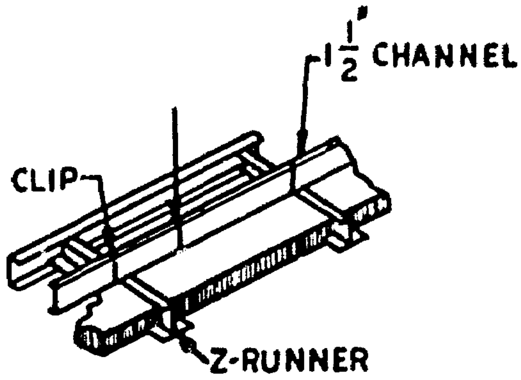

FIG. 16-1

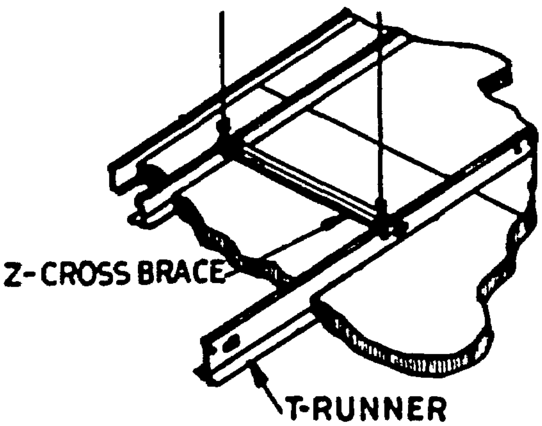

FIG. 16-2

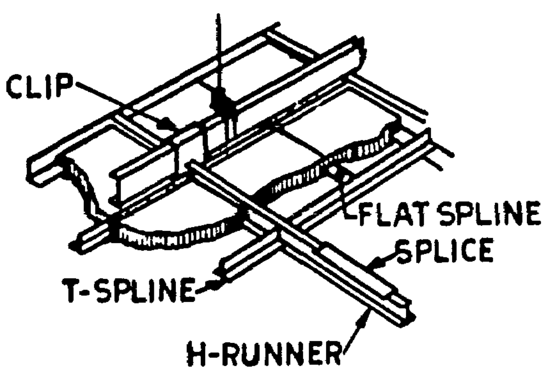

FIG. 16-3

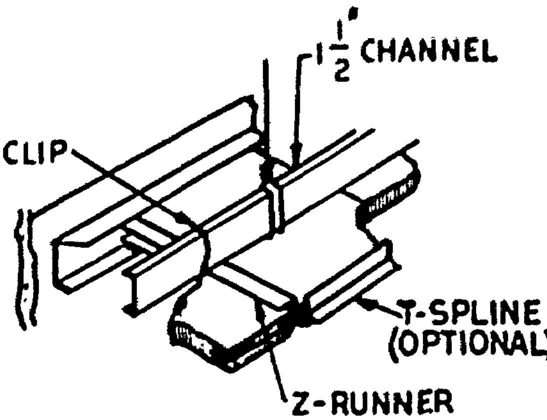

FIG. 16-4

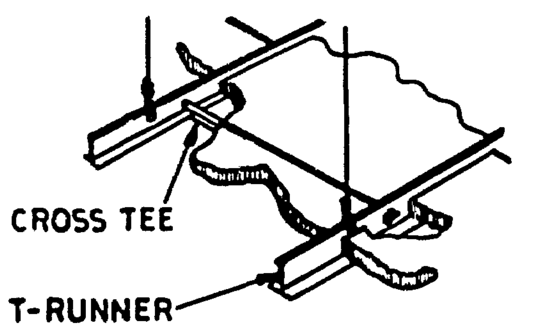

FIG. 16-5

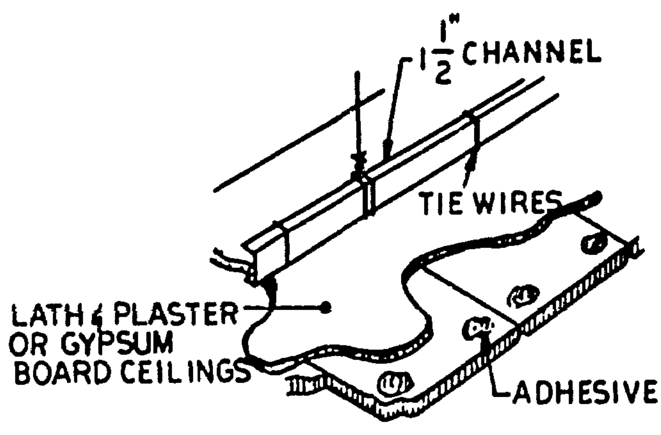

FIG. 16-6

CHAPTER XVIII

SPECIALTIES
(Wood Veneer, Cork Walls, Folding Doors, Fire Extinguishers, Sprinklers, Signs)

WOOD VENEER is a form of plywood in which an outer layer is chosen for its appearance rather than for its strength and is usually much thinner than the core. Both outside layers may be of some decorative wood. The core of veneer stock is usually made of a soft wood of cheaper quality, one that can be worked easily and always stays in shape well. This is the type of plywood used in furniture panels, giving a combination of strength and beauty of grain. The sizes are approximately the same as those of ordinary plywood, but the cost of the veneer stock depends upon the price of the wood on the outside layers.

Wood Veneer Panelling is also a form of plywood in which the outer layer is chosen for its appearance rather than its strength, except that only one side of the wood veneer panelling has a selected layer of decorative wood. It is made in several thicknesses, the most common being 5/32 and 1/4 inch. Veneer panels are used primarily for decor and can be installed over most any surface:

Concrete and Masonry Block Walls
Wood Stud Walls
Plywood Walls
Gypsum Plaster Board Walls
Plaster Walls

Concrete and Masonry Block Walls require that furring strips of 1 x 2 inch stock be attached to the concrete and masonry surfaces prior to applying the veneer panels. If concrete and masonry block is exterior, it is recommended that a vapor barrier of asphalt impregnated paper at least 15 lbs be applied under the furring strips to prevent moisture from warping, shrinking or swelling the wood veneer. Furring strips should be a minimum of 16 inches on center both vertically and horizontally to prevent buckling. Wood veneer should be applied to the furring strip lattice, after running a bead of panel adhesive approximately 1/4 inch thick along all wood strips and then nailed with color matching twist nails recommended by the manufacturers to assure a bond to the frame.

Wood Studs should be a maximum of 16 inches on center, again run a 1/4 inch bead of adhesive and secure with matching nails, spacing as necessary to hold panel in place until bonded. A minimum of 1/4 inch panel should be used over studs.

Plywood Walls must have all nails slightly counter sunk, and all joints smooth and free of paint to use adhesive. When veneer is applied over unpainted plywood only a minimum of nailing is required--just enough to hold panels flush to wall until adhesive has set and bonded.

Gypsum Plaster Board Walls unpainted make an excellent backing for veneer panels. The adhesive is applied vertically at approximately 16 inches on center using 1/4 inch beads of adhesive. Only enough nails are used to prevent panels from buckling until adhesive is set and bonded to the plaster board and the back of the panel.

Plaster Walls are also an excellent backing for veneer and panels are applied in the same manner as for gypsum plaster board.

Wood veneers are manufactured in sizes of 4 x 8, 4 x 10 and 4 x 12 feet. The 4 x 10 and 4 x 12 feet sizes are usually not stocked and must be specially ordered.

There are other wall veneers manufactured that give the appearance of wood such as masonite and linoleum. Some have embossed finishes and some have photographed finishes.

Mouldings are usually available to match the panels. Nails and matching color wax sticks are usually available to correct minor nicks and marks that occur during installation.

CORK WALL panels are usually applied in 6 x 6 and 12 x 12 inch squares -- backing must be smooth and level. Cork is fragile and must be handled with great care. Adhesives are used to secure it to wall and ceiling surfaces. It is used primarily for architectural effect. It is usually applied to surfaces not subject to grease, smoke and heavy traffic. It is difficult to clean because of the many surface openings. Cork can be obtained in many sizes and shapes through specialty manufacturers and usually require special ordering.

FOLDING DOORS are many and varied, manufactured of primarily vinyl and wood. The commercial folding doors are usually plywood veneer and because of the large openings they are generally required to fill, they are heavy. Folding doors used for closing off areas of auditoriums and convention halls can weigh 2,000 pounds and much more depending upon the opening. Since many folding doors are suspended from an overhead track, care must be exercised in the design and construction of the overhead supporting members. When the doors are folded back, the loads are concentrated to the sides of the opening.

FIRE EXTINGUISHERS are selected on the basis of National Fire Protection Agency (NFPA) Code. Each building is rated by the occupancy and function within the structure. Local or emergency installed fire fighting devices and facilities are specified by the Architect/Engineer on the basis of NFPA requirements.

In high risk areas where highly combustible items are stored, or in areas where industrial operations require a high degree of protection, usually water sprinkler systems are required. Water sprinkler systems are a series of pipes installed below the ceiling area and designed with sprinkler heads attached which cover a specified area. The sprinkler heads are so arranged that they overlap the areas they spray. There are two types of sprinkler systems:

Dry System
Wet System

Dry System piping is filled with air under enough pressure to just hold back the water which is valved at the source entering the facility. When a sprinkler head is activated, the air pressure is released allowing the valve to open and water immediately flows to the open sprinkler head and sprays the area. This type of system is usually installed in areas subject to freezing.

Wet System piping has water under pressure always up to the sprinkler head ready to spray out if the sprinkler head is activated. The system is usually installed in areas not subject to freezing or protected with adequate heating.

SIGNS

All commercial type facilities require signs of one sort or another, the most common being:

- Building Identification
- Fire Exits
- Entrances
- Door Numbering
- Office and Area Identification
- Directional Signs in Hallways
- Parking Area Directional Signs
- Reserved Area Signs
- Directory Bulletin Boards in Lobbys and Individual Floor Directories
- Fire Extinguisher and Apparatus Location Signs
- Elevator Signs
- Signs for High Voltage and Dangerous Equipment
- Construction Signs

Signs should be carefully specified in the contract documents and located on a contract drawing. Signs to be effective should be clear, concise and properly displayed in locations that will leave no doubt of their intent and purpose. All signs should meet the standard of the Occupational Safety and Health Act (OSHA), National Safety Council (NSC) or the National Fire Protection Association (NFPA). However, fire related signs should be checked against <u>local fire ordinances</u> and <u>must be checked for required colors</u>.

With the exception of specialized signs, almost any of the common use signs are available from Supply Company stocks, and most meet the standards of OSHA, NSC, and NFPA.

CHAPTER XIX

PRELIMINARY AND FINAL INSPECTION

Preliminary Inspection. This is usually performed by the Architect/Engineer, together with his Representative and the Contractor's Superintendent. At this point in time of the contract completion, punch lists prepared by the Architect/Engineer's Representative should have already been submitted to the Contractor far enough in advance so that the items listed were completed, corrected and re-inspected by the Architect/Engineer's Representative. The preliminary inspection is usually performed just prior to final acceptance of the project, allowing enough time for the Contractor to make the necessary corrections or adjustments before final inspection and acceptance. During the preliminary inspection the project is inspected for any unfinished items of work, quality of workmanship, errors or unacceptable finish treatment such as wall finishes, floor stains or improper installation of base and core moldings, ceilings, doors and hardware. It is at this time the Contractor should demonstrate the proper operation of utilities and mechanical and electrical items. The systems should have been balanced and checked out prior to the preliminary inspection, so that only a spot check with instruments by the Architect/Engineer is required. It is during the preliminary inspection that dates and times are agreed upon for the Contractor to provide training for the Owner's maintenance and engineering staff in the proper operation of all electrical and mechanical equipment. The final detailed punch list is prepared and submitted to the Contractor.

Final Inspection and Acceptance is performed by the Owner, Architect/Engineer, Architect/Engineer's Representative, Contractor and any other principals involved in the project and invited. The final inspection should be little more than a walk through, if the Architect/Engineer's Representative and the Contractor's Superintendent carried out their responsibilities after the preliminary inspection. Usually the Architect/Engineer conducts the final inspection, pointing out to the Owner the principal features of his design and function of the facility. Specialty items and decor are usually of prime interest to the Owner. This is why extreme care must be exercised to prevent any marring or damage to the finish of the building during the final stages of construction.

The Architect/Engineer's Representative should be prepared to turn over to the Owner or the Owner's Representative the following items:

1. Keys to all doors, properly tagged or in a key cabinet if the contract requires it.

2. All Guarantees and Warrantees.

3. Special instructions for specialty items.

4. As Built drawings and plans.

5. Descriptive data, catalogue cuts and catalogues of project items.

6. Maintenance manuals, parts' lists, diagrams, charts and functional information for utilities -- electrical and mechanical -- for the entire project.

Final Payment to the Contractor is normally executed by the Architect/Engineer to the Owner, after the Architect/Engineer's Representative has determined to the best of his knowledge and belief, based upon his observance of the work, that the project conforms to the contract documents and that the quality of the workmanship is acceptable.

Final Certification should only be made when it has been determined that no faults or non-conformances exist. The final certification by the Architect/Engineer does not represent that all the work in detail has been performed by the Contractor--no person could certify to this due to the complexity and numerous items involved in construction. This should be made clear to the Owners. Most contracts contain a clause that provides the Owner a guarantee on workmanship for one year after acceptance and also for latent defects and omissions that could not be reasonably observed during inspection, such as concealed items; therefore, final payment does not relieve the Contractor from responsibility toward the project for the guarantee period. Final payment means that the Owner must depend on the Contractor's integrity to remedy defective work or go through lengthy litigation unless there is a performance bond contract clause which permits redress to a bonding company for one year after acceptance and this could also lead to lengthy litigation. Because of this it is necessary that diligent observation of the work should be conducted by the Architect/Engineer's Representative before a final certificate is executed.

CONCLUSIONS

The highly complex construction projects of today require materials and equipment from many remote areas of the United States and in many cases remote parts of the world. To assemble the many parts and pieces to form a completed facility requires skill and knowledge of general building construction to a higher degree than ever before. As times change and the State-of-the-Art becomes even more complex, the Architect/Engineer and his Representative must continue to update their learning and thinking processes to meet the challenges of tomorrow.

The role of the Inspector will require advanced knowledge in construction techniques and management. His skill in dealing with Contractors, as well as his ability to inspect and interpret contract documents make him a necessary and valuable member of the Architect/Engineer and Owner's staff.

AIA Document B352

Duties, Responsibilities and Limitations of Authority Of Full-Time Project Representative

Recommended as an Exhibit to the Owner-Architect Agreement When a Full-Time Project Representative is Employed

1. EXPLAIN CONTRACT DOCUMENTS

Assist the Contractor's superintendent in understanding the intent of the Contract Documents.

2. OBSERVATIONS

Conduct on-site observations and spot checks of the Work in progress as a basis for determining conformance of Work, materials and equipment with the Contract Documents. Report any defective Work to the Architect.

3. ADDITIONAL INFORMATION

Obtain from the Architect additional details or information if, and when, required at the site for proper execution of the Work. Become acquainted with standard or reference specifications referred to in the Specifications.

4. CONTRACTOR'S SUGGESTIONS

Consider and evaluate suggestions or recommendations which may be submitted by the Contractor to the Architect and report them with recommendations to the Architect for final decision.

5. CONSTRUCTION SCHEDULE

Be alert to the construction schedule and to conditions which may cause delay in completion, and report same to the Architect.

6. LIAISON

Maintain liaison with the Contractor and all subcontractors on the Project only through the Contractor's superintendent.

7. CONFERENCES

Attend and report to the Architect on conferences held at the Project site as directed by the Architect.

8. TESTS

Advise the Architect's office in advance of the schedules of tests and observe that tests at the Project site which are required by the Contract Documents are actually conducted; observe, record and report to the Architect all details relative to the test procedures.

9. INSPECTIONS BY OTHERS

If inspectors representing local, state or federal agencies having jurisdiction over the Project visit the site, accompany such inspectors during their trips through the Project, record and report to the Architect's office the results of these inspections.

10. RECORDS

10.1 Maintain orderly files at the site for (1) correspondence, (2) reports of site conferences, (3) shop drawings and (4) reproductions of original Contract Documents including all Addenda, Change Orders and supplementary Drawings issued subsequent to the award of the Contract.

10.2 Keep a daily diary or log book, recording hours on the site, weather conditions, list of visiting officials and jurisdiction, daily activities, decisions, observations in general, and specific observations in more detail as in the case of observing test procedures.

10.3 Record names, addresses and telephone numbers of all contractors and subcontractors.

11. SHOP DRAWINGS

The Contractor is not authorized to install any materials and equipment for which shop drawings are required unless such drawings have been approved in accordance with the General Conditions by the Contractor and the Architect.

12. SAMPLES

Receive samples which are required to be furnished at the site; record date received and from whom, and notify the Architect of their readiness for examination; record Architect's approval or rejection; and maintain custody of approved samples.

13. CONTRACTOR'S APPLICATIONS FOR PAYMENT

Review the Applications for Payment submitted by the Contractor and forward them with recommendations to the Architect for disposition.

14. LIST OF ITEMS FOR CORRECTION

After Substantial Completion, check each item as it is corrected.

15. OWNER'S OCCUPANCY OF THE PROJECT

If the Owner occupies the Project or any portion thereof prior to final completion of the Work by the Contractor, be especially alert to possibilities of claims for damage to Work completed prior to occupancy.

16. OWNER'S EXISTING OPERATION

In the case of additions to or renovations of an existing facility which must be maintained in operation during construction, be alert to conditions which could have an effect on the Owner's existing operation.

17. REJECTION OF WORK

If a situation arises during construction which in your view requires that Work be rejected, report such situation immediately to the Architect.

18. LIMITATIONS OF AUTHORITY

Unless specific exceptions are established by written instructions issued by the Architect:

18.1 Do not authorize deviations from the Contract Documents.

18.2 Do not personally conduct any tests.

18.3 Do not enter into the area of responsibility of the Contractor's superintendent.

18.4 Do not expedite the Work for the Contractor.

18.5 Do not advise on, or issue directions relative to, any aspect of construction means, methods, techniques, sequences or procedures, or for safety precautions and programs in connection with the Work.

18.6 Do not authorize or suggest that the Owner occupy the Project, in whole or in part, prior to Substantial Completion.

18.7 Do not issue a Certificate for Payment.

THE AMERICAN INSTITUTE OF ARCHITECTS

AIA Document A201

General Conditions of the Contract for Construction

THIS DOCUMENT HAS IMPORTANT LEGAL CONSEQUENCES; CONSULTATION WITH AN ATTORNEY IS ENCOURAGED WITH RESPECT TO ITS MODIFICATION

TABLE OF ARTICLES

This document has been approved and endorsed by The Associated General Contractors of America.

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INDEX

GENERAL CONDITIONS OF THE CONTRACT FOR CONSTRUCTION

ARTICLE 1

CONTRACT DOCUMENTS

1.1 DEFINITIONS

1.1.1 THE CONTRACT DOCUMENTS

The Contract Documents consist of the Agreement, the Conditions of the Contract (General, Supplementary and other Conditions), the Drawings, the Specifications, all Addenda issued prior to execution of the Contract, and all Modifications thereto. A Modification is (1) a written amendment to the Contract signed by both parties, (2) a Change Order, (3) a written interpretation issued by the Architect pursuant to Subparagraph 1.2.5, or (4) a written order for a minor change in the Work issued by the Architect pursuant to Paragraph 12.3. A Modification may be made only after execution of the Contract.

1.1.2 THE CONTRACT

The Contract Documents form the Contract. The Contract represents the entire and integrated agreement between the parties hereto and supersedes all prior negotiations, representations, or agreements, either written or oral, including the bidding documents. The Contract may be amended or modified only by a Modification as defined in Subparagraph 1.1.1.

1.1.3 THE WORK

The term Work includes all labor necessary to produce the construction required by the Contract Documents, and all materials and equipment incorporated or to be incorporated in such construction.

1.1.4 THE PROJECT

The Project is the total construction designed by the Architect of which the Work performed under the Contract Documents may be the whole or a part.

1.2 EXECUTION, CORRELATION, INTENT AND INTERPRETATIONS

1.2.1 The Contract Documents shall be signed in not less than triplicate by the Owner and Contractor. If either the Owner or the Contractor or both do not sign the Conditions of the Contract, Drawings, Specifications, or any of the other Contract Documents, the Architect shall identify them.

1.2.2 By executing the Contract, the Contractor represents that he has visited the site, familiarized himself with the local conditions under which the Work is to be performed, and correlated his observations with the requirements of the Contract Documents.

1.2.3 The Contract Documents are complementary, and what is required by any one shall be as binding as if required by all. The intention of the Documents is to include all labor, materials, equipment and other items as provided in Subparagraph 4.4.1 necessary for the proper execution and completion of the Work. It is not intended that Work not covered under any heading, section, branch, class or trade of the Specifications shall be supplied unless it is required elsewhere in the Contract Documents or is reasonably inferable therefrom as being necessary to produce the intended results. Words which have well-known technical or trade meanings are used herein in accordance with such recognized meanings.

1.2.4 The organization of the Specifications into divisions, sections and articles, and the arrangement of Drawings shall not control the Contractor in dividing the Work among Subcontractors or in establishing the extent of Work to be performed by any trade.

1.2.5 Written interpretations necessary for the proper execution or progress of the Work, in the form of drawings or otherwise, will be issued with reasonable promptness by the Architect and in accordance with any schedule agreed upon. Either party to the Contract may make written request to the Architect for such interpretations. Such interpretations shall be consistent with and reasonably inferable from the Contract Documents, and may be effected by Field Order.

1.3 COPIES FURNISHED AND OWNERSHIP

1.3.1 Unless otherwise provided in the Contract Documents, the Contractor will be furnished, free of charge, all copies of Drawings and Specifications reasonably necessary for the execution of the Work.

1.3.2 All Drawings, Specifications and copies thereof furnished by the Architect are and shall remain his property. They are not to be used on any other project, and, with the exception of one contract set for each party to the Contract, are to be returned to the Architect on request at the completion of the Work.

ARTICLE 2

ARCHITECT

2.1 DEFINITION

2.1.1 The Architect is the person or organization licensed to practice architecture and identified as such in the Agreement and is referred to throughout the Contract Documents as if singular in number and masculine in gender. The term Architect means the Architect or his authorized representative.

2.1.2 Nothing contained in the Contract Documents shall create any contractual relationship between the Architect and the Contractor.

2.2 ADMINISTRATION OF THE CONTRACT

2.2.1 The Architect will provide general Administration of the Construction Contract, including performance of the functions hereinafter described.

2.2.2 The Architect will be the Owner's representative during construction and until final payment. The Architect will have authority to act on behalf of the Owner to the extent provided in the Contract Documents, unless otherwise modified by written instrument which will be shown to the Contractor. The Architect will advise and consult with the Owner, and all of the Owner's instructions to the Contractor shall be issued through the Architect.

2.2.3 The Architect shall at all times have access to the Work wherever it is in preparation and progress. The Contractor shall provide facilities for such access so the Architect may perform his functions under the Contract Documents.

2.2.4 The Architect will make periodic visits to the site to familiarize himself generally with the progress and quality of the Work and to determine in general if the Work is proceeding in accordance with the Contract Documents. On the basis of his on-site observations as an architect, he will keep the Owner informed of the progress of the Work, and will endeavor to guard the Owner against defects and deficiencies in the Work of the Contractor. The Architect will not be required to make exhaustive or continuous on-site inspections to check the quality or quantity of the Work. The Architect will not be responsible for construction means, methods, techniques, sequences or procedures, or for safety precautions and programs in connection with the Work, and he will not be responsible for the Contractor's failure to carry out the Work in accordance with the Contract Documents.

2.2.5 Based on such observations and the Contractor's Applications for Payment, the Architect will determine the amounts owing to the Contractor and will issue Certificates for Payment in such amounts, as provided in Paragraph 9.4.

2.2.6 The Architect will be, in the first instance, the interpreter of the requirements of the Contract Documents and the judge of the performance thereunder by both the Owner and Contractor. The Architect will, within a reasonable time, render such interpretations as he may deem necessary for the proper execution or progress of the Work.

2.2.7 Claims, disputes and other matters in question between the Contractor and the Owner relating to the execution or progress of the Work or the interpretation of the Contract Documents shall be referred initially to the Architect for decision which he will render in writing within a reasonable time.

2.2.8 All interpretations and decisions of the Architect shall be consistent with the intent of the Contract Documents. In his capacity as interpreter and judge, he will exercise his best efforts to insure faithful performance by both the Owner and the Contractor and will not show partiality to either.

2.2.9 The Architect's decisions in matters relating to artistic effect will be final if consistent with the intent of the Contract Documents.

2.2.10 Any claim, dispute or other matter that has been referred to the Architect, except those relating to artistic effect as provided in Subparagraph 2.2.9 and except any which have been waived by the making or acceptance of final payment as provided in Subparagraphs 9.7.5 and 9.7.6, shall be subject to arbitration upon the written demand of either party. However, no demand for arbitration of any such claim, dispute or other matter may be made until the earlier of:

2.2.10.1 The date on which the Architect has rendered his written decision, or

.2 the tenth day after the parties have presented their evidence to the Architect or have been given a reasonable opportunity to do so, if the Architect has not rendered his written decision by that date.

2.2.11 If a decision of the Architect is made in writing and states that it is final but subject to appeal, no demand for arbitration of a claim, dispute or other matter covered by such decision may be made later than thirty days after the date on which the party making the demand received the decision. The failure to demand arbitration within said thirty days' period will result in the Architect's decision becoming final and binding upon the Owner and the Contractor. If the Architect renders a decision after arbitration proceedings have been initiated, such decision may be entered as evidence but will not supersede any arbitration proceedings unless the decision is acceptable to the parties concerned.

2.2.12 The Architect will have authority to reject Work which does not conform to the Contract Documents. Whenever, in his reasonable opinion, he considers it necessary or advisable to insure the proper implementation of the intent of the Contract Documents, he will have authority to require special inspection or testing of the Work in accordance with Subparagraph 7.8.2 whether or not such Work be then fabricated, installed or completed. However, neither the Architect's authority to act under this Subparagraph 2.2.12, nor any decision made by him in good faith either to exercise or not to exercise such authority, shall give rise to any duty or responsibility of the Architect to the Contractor, any Subcontractor, any of their agents or employees, or any other person performing any of the Work.

2.2.13 The Architect will review Shop Drawings and Samples as provided in Subparagraphs 4.13.1 through 4.13.8 inclusive.

2.2.14 The Architect will prepare Change Orders in accordance with Article 12, and will have authority to order minor changes in the Work as provided in Subparagraph 12.3.1.

2.2.15 The Architect will conduct inspections to determine the dates of Substantial Completion and final completion, will receive and review written guarantees and related documents required by the Contract and assembled by the Contractor and will issue a final Certificate for Payment.

2.2.16 If the Owner and Architect agree, the Architect will provide one or more Full-Time Project Representatives to assist the Architect in carrying out his responsibilities at the site. The duties, responsibilities and limitations of authority of any such Project Representative shall be as set forth in an exhibit to be incorporated in the Contract Documents.

2.2.17 The duties, responsibilities and limitations of authority of the Architect as the Owner's representative during construction as set forth in Articles 1 through 14 inclusive of these General Conditions will not be modified or extended without written consent of the Owner, the Contractor and the Architect.

2.2.18 The Architect will not be responsible for the acts or omissions of the Contractor, any Subcontractors, or any of their agents or employees, or any other persons performing any of the Work.

2.2.19 In case of the termination of the employment of the Architect, the Owner shall appoint an architect against whom the Contractor makes no reasonable objection whose status under the Contract Documents shall be that of the former architect. Any dispute in connection with such appointment shall be subject to arbitration.

ARTICLE 3

OWNER

3.1 DEFINITION

3.1.1 The Owner is the person or organization identified as such in the Agreement and is referred to throughout the Contract Documents as if singular in number and masculine in gender. The term Owner means the Owner or his authorized representative.

3.2 INFORMATION AND SERVICES REQUIRED OF THE OWNER

3.2.1 The Owner shall furnish all surveys describing the physical characteristics, legal limits and utility locations for the site of the Project.

3.2.2 The Owner shall secure and pay for easements for permanent structures or permanent changes in existing facilities.

3.2.3 Information or services under the Owner's control shall be furnished by the Owner with reasonable promptness to avoid delay in the orderly progress of the Work.

3.2.4 The Owner shall issue all instructions to the Contractor through the Architect.

3.2.5 The foregoing are in addition to other duties and responsibilities of the Owner enumerated herein and especially those in respect to Payment and Insurance in Articles 9 and 11 respectively.

3.3 OWNER'S RIGHT TO STOP THE WORK

3.3.1 If the Contractor fails to correct defective Work or persistently fails to supply materials or equipment in accordance with the Contract Documents, the Owner may order the Contractor to stop the Work, or any portion thereof, until the cause for such order has been eliminated.

3.4 OWNER'S RIGHT TO CARRY OUT THE WORK

3.4.1 If the Contractor defaults or neglects to carry out the Work in accordance with the Contract Documents or fails to perform any provision of the Contract, the Owner may, after seven days' written notice to the Contractor and without prejudice to any other remedy he may have, make good such deficiencies. In such case an appropriate Change Order shall be issued deducting from the payments then or thereafter due the Contractor the cost of correcting such deficiencies, including the cost of the Architect's additional services made necessary by such default, neglect or failure. The Architect must approve both such action and the amount charged to the Contractor. If the payments then or thereafter due the Contractor are not sufficient to cover such amount, the Contractor shall pay the difference to the Owner.

ARTICLE 4

CONTRACTOR

4.1 DEFINITION

4.1.1 The Contractor is the person or organization identified as such in the Agreement and is referred to throughout the Contract Documents as if singular in number and masculine in gender. The term Contractor means the Contractor or his authorized representative.

4.2 REVIEW OF CONTRACT DOCUMENTS

4.2.1 The Contractor shall carefully study and compare the Contract Documents and shall at once report to the Architect any error, inconsistency or omission he may discover. The Contractor shall not be liable to the Owner or the Architect for any damage resulting from any such errors, inconsistencies or omissions in the Contract Documents. The Contractor shall do no Work without Drawings, Specifications or Modifications.

4.3 SUPERVISION AND CONSTRUCTION PROCEDURES

4.3.1 The Contractor shall supervise and direct the Work, using his best skill and attention. He shall be solely responsible for all construction means, methods, techniques, sequences and procedures and for coordinating all portions of the Work under the Contract.

4.4 LABOR AND MATERIALS

4.4.1 Unless otherwise specifically noted, the Contractor shall provide and pay for all labor, materials, equipment, tools, construction equipment and machinery, water, heat, utilities, transportation, and other facilities and services necessary for the proper execution and completion of the Work.

4.4.2 The Contractor shall at all times enforce strict discipline and good order among his employees and shall not employ on the Work any unfit person or anyone not skilled in the task assigned to him.

4.5 WARRANTY

4.5.1 The Contractor warrants to the Owner and the Architect that all materials and equipment furnished under this Contract will be new unless otherwise specified, and that all Work will be of good quality, free from faults and defects and in conformance with the Contract Documents. All Work not so conforming to these standards may be considered defective. If required by the Architect, the Contractor shall furnish satisfactory evidence as to the kind and quality of materials and equipment.

4.6 TAXES

4.6.1 The Contractor shall pay all sales, consumer, use and other similar taxes required by law.

4.7 PERMITS, FEES AND NOTICES

4.7.1 The Contractor shall secure and pay for all permits, governmental fees and licenses necessary for the proper execution and completion of the Work, which are applicable at the time the bids are received. It is not the responsibility of the Contractor to make certain that the Drawings and Specifications are in accordance with applicable laws, statutes, building codes and regulations.

4.7.2 The Contractor shall give all notices and comply with all laws, ordinances, rules, regulations and orders of any public authority bearing on the performance of the Work. If the Contractor observes that any of the Contract Documents are at variance therewith in any respect, he shall promptly notify the Architect in writing, and any necessary changes shall be adjusted by appropriate Modification. If the Contractor performs any Work knowing it to be contrary to such laws, ordinances, rules and regulations, and without such notice to the Architect, he shall assume full responsibility therefor and shall bear all costs attributable thereto.

4.8 CASH ALLOWANCES

4.8.1 The Contractor shall include in the Contract Sum all allowances stated in the Contract Documents. These allowances shall cover the net cost of the materials and equipment delivered and unloaded at the site, and all applicable taxes. The Contractor's handling costs on the site, labor, installation costs, overhead, profit and other expenses contemplated for the original allowance shall be included in the Contract Sum and not in the allowance. The Contractor shall cause the Work covered by these allowances to be performed for such amounts and by such persons as the Architect may direct, but he will not be required to employ oersons against whom he makes a reasonable objection. If the cost, when determined, is more than or less than the allowance, the Contract Sum shall be adjusted accordingly by Change Order which will include additional handling costs on the site, labor, installation costs, overhead, profit and other expenses resulting to the Contractor from any increase over the original allowance.

4.9 SUPERINTENDENT

4.9.1 The Contractor shall employ a competent superintendent and necessary assistants who shall be in attendance at the Project site during the progress of the Work. The superintendent shall be satisfactory to the Architect, and shall not be changed except with the consent of the Architect, unless the superintendent proves to be unsatisfactory to the Contractor and ceases to be in his employ. The superintendent shall represent the Contractor and all communications given to the superintendent shall be as binding as if given to the Contractor. Important communications will be confirmed in writing. Other communications will be so confirmed on written request in each case.

4.10 RESPONSIBILITY FOR THOSE PERFORMING THE WORK

4.10.1 The Contractor shall be responsible to the Owner for the acts and omissions of all his employees and all Subcontractors, their agents and employees, and all other persons performing any of the Work under a contract with the Contractor.

4.11 PROGRESS SCHEDULE

4.11.1 The Contractor, immediately after being awarded the Contract, shall prepare and submit for the Architect's approval an estimated progress schedule for the Work. The progress schedule shall be related to the entire Project to the extent required by the Contract Documents. This schedule shall indicate the dates for the starting and completion of the various stages of construction and shall be revised as required by the conditions of the Work, subject to the Architect's approval.

4.12 DRAWINGS AND SPECIFICATIONS AT THE SITE

4.12.1 The Contractor shall maintain at the site for the Owner one copy of all Drawings, Specifications, Addenda, approved Shop Drawings, Change Orders and other Modifications, in good order and marked to record all changes made during construction. These shall be available to the Architect. The Drawings, marked to record all changes made during construction, shall be delivered to him for the Owner upon completion of the Work.

4.13 SHOP DRAWINGS AND SAMPLES

4.13.1 Shop Drawings are drawings, diagrams, illustrations, schedules, performance charts, brochures and other data which are prepared by the Contractor or any Subcontractor, manufacturer, supplier or distributor, and which illustrate some portion of the Work.

4.13.2 Samples are physical examples furnished by the Contractor to illustrate materials, equipment or workmanship, and to establish standards by which the Work will be judged.

4.13.3 The Contractor shall review, stamp with his approval and submit, with reasonable promptness and in orderly sequence so as to cause no delay in the Work or in the work of any other contractor, all Shop Drawings and Samples required by the Contract Documents or subsequently by the Architect as covered by Modifications. Shop Drawings and Samples shall be properly identified as specified, or as the Architect may require. At the time of submission the Contractor shall inform the Architect in writing of any deviation in the Shop Drawings or Samples from the requirements of the Contract Documents.

4.13.4 By approving and submitting Shop Drawings and Samples, the Contractor thereby represents that he has determined and verified all field measurements, field construction criteria, materials, catalog numbers and similar data, or will do so, and that he has checked and coordinated each Shop Drawing and Sample with the requirements of the Work and of the Contract Documents.

4.13.5 The Architect will review and approve Shop Drawings and Samples with reasonable promptness so as to cause no delay, but only for conformance with the design concept of the Project and with the information given in the Contract Documents. The Architect's approval of a separate item shall not indicate approval of an assembly in which the item functions.

4.13.6 The Contractor shall make any corrections required by the Architect and shall resubmit the required number of corrected copies of Shop Drawings or new Samples until approved. The Contractor shall direct specific attention in writing or on resubmitted Shop Drawings to revisions other than the corrections requested by the Architect on previous submissions.

4.13.7 The Architect's approval of Shop Drawings or Samples shall not relieve the Contractor of responsibility for any deviation from the requirements of the Contract Documents unless the Contractor has informed the Architect in writing of such deviation at the time of submission and the Architect has given written approval to the specific deviation, nor shall the Architect's approval relieve the Contractor from responsibility for errors or omissions in the Shop Drawings or Samples.

4.13.8 No portion of the Work requiring a Shop Drawing or Sample submission shall be commenced until the submission has been approved by the Architect. All such portions of the Work shall be in accordance with approved Shop Drawings and Samples.

4.14 USE OF SITE

4.14.1 The Contractor shall confine operations at the site to areas permitted by law, ordinances, permits and the Contract Documents and shall not unreasonably encumber the site with any materials or equipment.

4.15 CUTTING AND PATCHING OF WORK

4.15.1 The Contractor shall do all cutting, fitting or patching of his Work that may be required to make its several parts fit together properly, and shall not endanger any Work by cutting, excavating or otherwise altering the Work or any part of it.

4.16 CLEANING UP

4.16.1 The Contractor at all times shall keep the premises free from accumulation of waste materials or rubbish caused by his operations. At the completion of the Work he shall remove all his waste materials and rubbish from and about the Project as well as all his tools, construction equipment, machinery and surplus materials, and shall clean all glass surfaces and leave the Work "broom-clean" or its equivalent, except as otherwise specified.

4.16.2 If the Contractor fails to clean up, the Owner may do so and the cost thereof shall be charged to the Contractor as provided in Paragraph 3.4.

4.17 COMMUNICATIONS

4.17.1 The Contractor shall forward all communications to the Owner through the Architect.

4.18 INDEMNIFICATION

4.18.1 The Contractor shall indemnify and hold harmless the Owner and the Architect and their agents and employees from and against all claims, damages, losses and expenses including attorneys' fees arising out of or resulting from the performance of the Work, provided that any such claim, damage, loss or expense (1) is attributable to bodily injury, sickness, disease or death, or to injury to or destruction of tangible property (other than the Work itself) including the loss of use resulting therefrom, and (2) is caused in whole or in part by any negligent act or omission of the Contractor, any Subcontractor, anyone directly or indirectly employed by any of them or anyone for whose acts any of them may be liable, regardless of whether or not it is caused in part by a party indemnified hereunder.

4.18.2 In any and all claims against the Owner or the Architect or any of their agents or employees by any employee of the Contractor, any Subcontractor, anyone directly or indirectly employed by any of them or anyone for whose acts any of them may be liable, the indemnification obligation under this Paragraph 4.18 shall not be limited in any way by any limitation on the amount or type of damages, compensation or benefits payable by or for the Contractor or any Subcontractor under workmen's compensation acts, disability benefit acts or other employee benefit acts.

4.18.3 The obligations of the Contractor under this Paragraph 4.18 shall not extend to the liability of the Architect, his agents or employees arising out of (1) the preparation or approval of maps, drawings, opinions, reports, surveys, Change Orders, designs or specifications, or (2) the giving of or the failure to give directions or instructions by the Architect, his agents or employees provided such giving or failure to give is the primary cause of the injury or damage.

ARTICLE 5

SUBCONTRACTORS

5.1 DEFINITION

5.1.1 A Subcontractor is a person or organization who has a direct contract with the Contractor to perform any of the Work at the site. The term Subcontractor is referred to throughout the Contract Documents as if singular in number and masculine in gender and means a Subcontractor or his authorized representative.

5.1.2 A Sub-subcontractor is a person or organization who has a direct or indirect contract with a Subcontractor to perform any of the Work at the site. The term Sub-subcontractor is referred to throughout the Contract Documents as if singular in number and masculine in gender and means a Sub-subcontractor or an authorized representative thereof.

5.1.3 Nothing contained in the Contract Documents shall create any contractual relation between the Owner or the Architect and any Subcontractor or Sub-subcontractor.

5.2 AWARD OF SUBCONTRACTS AND OTHER CONTRACTS FOR PORTIONS OF THE WORK

5.2.1 Unless otherwise specified in the Contract Documents or in the Instructions to Bidders, the Contractor, as soon as practicable after the award of the Contract, shall furnish to the Architect in writing for acceptance by the Owner and the Architect a list of the names of the Subcontractors proposed for the principal portions of the Work. The Architect shall promptly notify the Contractor in writing if either the Owner or the Architect, after due investigation, has reasonable objection to any Subcontractor on such list and does not accept him. Failure of the Owner or Architect to make objection promptly to any Subcontractor on the list shall constitute acceptance of such Subcontractor.

5.2.2 The Contractor shall not contract with any Subcontractor or any person or organization (including those who are to furnish materials or equipment fabricated to a special design) proposed for portions of the Work designated in the Contract Documents or in the Instructions to Bidders or, if none is so designated, with any Subcontractor proposed for the principal portions of the Work who has been rejected by the Owner and the Architect. The Contractor will not be required to contract with any Subcontractor or person or organization against whom he has a reasonable objection.

5.2.3 If the Owner or Architect refuses to accept any Subcontractor or person or organization on a list submitted by the Contractor in response to the requirements of the Contract Documents or the Instructions to Bidders, the Contractor shall submit an acceptable substitute and the Contract Sum shall be increased or decreased by the difference in cost occasioned by such substitution and an appropriate Change Order shall be issued; however, no increase in the Contract Sum shall be allowed for any such substitution unless the Contractor has acted promptly and responsively in submitting for acceptance any list or lists of names as required by the Contract Documents or the Instructions to Bidders.

5.2.4 If the Owner or the Architect requires a change of any proposed Subcontractor or person or organization previously accepted by them, the Contract Sum shall be increased or decreased by the difference in cost occasioned by such change and an appropriate Change Order shall be issued.

5.2.5 The Contractor shall not make any substitution for any Subcontractor or person or organization who has been accepted by the Owner and the Architect, unless the substitution is acceptable to the Owner and the Architect.

5.3 SUBCONTRACTUAL RELATIONS

5.3.1 All work performed for the Contractor by a Subcontractor shall be pursuant to an appropriate agreement between the Contractor and the Subcontractor (and where appropriate between Subcontractors and Sub-subcontractors) which shall contain provisions that:

.1 preserve and protect the rights of the Owner and the Architect under the Contract with respect to the Work to be performed under the subcontract so that the subcontracting thereof will not prejudice such rights;

.2 require that such Work be performed in accordance with the requirements of the Contract Documents;

.3 require submission to the Contractor of applications for payment under each subcontract to which the Contractor is a party, in reasonable time to enable the Contractor to apply for payment in accordance with Article 9;

.4 require that all claims for additional costs, extensions of time, damages for delays or otherwise with respect to subcontracted portions of the Work shall be submitted to the Contractor (via any Subcontractor or Sub-subcontractor where appropriate) in sufficient time so that the Contractor may comply in the manner provided in the Contract Documents for like claims by the Contractor upon the Owner;

.5 waive all rights the contracting parties may have against one another for damages caused by fire or other perils covered by the property insurance described in Paragraph 11.3, except such rights as they may have to the proceeds of such insurance held by the Owner as trustee under Paragraph 11.3; and

.6 obligate each Subcontractor specifically to consent to the provisions of this Paragraph 5.3.

5.4 PAYMENTS TO SUBCONTRACTORS

5.4.1 The Contractor shall pay each Subcontractor, upon receipt of payment from the Owner, an amount equal to the percentage of completion allowed to the Contractor on account of such Subcontractor's Work, less the percentage retained from payments to the Contractor. The Contractor shall also require each Subcontractor to make similar payments to his subcontractors.

5.4.2 If the Architect fails to issue a Certificate for Payment for any cause which is the fault of the Contractor and not the fault of a particular Subcontractor, the Contractor shall pay that Subcontractor on demand, made at any time after the Certificate for Payment should otherwise have been issued, for his Work to the extent completed, less the retained percentage.

5.4.3 The Contractor shall pay each Subcontractor a just share of any insurance moneys received by the Contractor under Article 11, and he shall require each Subcontractor to make similar payments to his subcontractors.

5.4.4 The Architect may, on request and at his discretion, furnish to any Subcontractor, if practicable, information regarding percentages of completion certified to the Contractor on account of Work done by such Subcontractors.

5.4.5 Neither the Owner nor the Architect shall have any obligation to pay or to see to the payment of any moneys to any Subcontractor except as may otherwise be required by law.

ARTICLE 6

SEPARATE CONTRACTS

6.1 OWNER'S RIGHT TO AWARD SEPARATE CONTRACTS

6.1.1 The Owner reserves the right to award other contracts in connection with other portions of the Project under these or similar Conditions of the Contract.

6.1.2 When separate contracts are awarded for different portions of the Project, "the Contractor" in the contract documents in each case shall be the contractor who signs each separate contract.

6.2 MUTUAL RESPONSIBILITY OF CONTRACTORS

6.2.1 The Contractor shall afford other contractors reasonable opportunity for the introduction and storage of their materials and equipment and the execution of their work, and shall properly connect and coordinate his Work with theirs.

6.2.2 If any part of the Contractor's Work depends for proper execution or results upon the work of any other separate contractor, the Contractor shall inspect and promptly report to the Architect any apparent discrepancies or defects in such work that render it unsuitable for such proper execution and results. Failure of the Contractor so to inspect and report shall constitute an acceptance of the other contractor's work as fit and proper to receive his Work, except as to defects which may develop in the other separate contractor's work after the execution of the Contractor's Work.

6.2.3 Should the Contractor cause damage to the work or property of any separate contractor on the Project, the Contractor shall, upon due notice, settle with such other contractor by agreement or arbitration, if he will so settle. If such separate contractor sues the Owner or initiates an arbitration proceeding on account of any damage alleged to have been so sustained, the Owner shall notify the Contractor who shall defend such proceedings at the Owner's expense, and if any judgment or award against the Owner arises therefrom the Contractor shall pay or satisfy it and shall reimburse the Owner for all attorneys' fees and court or arbitration costs which the Owner has incurred.

6.3 CUTTING AND PATCHING UNDER SEPARATE CONTRACTS

6.3.1 The Contractor shall be responsible for any cutting, fitting and patching that may be required to complete his Work except as otherwise specifically provided in the Contract Documents. The Contractor shall not endanger any work of any other contractors by cutting, excavating or otherwise altering any work and shall not cut or alter the work of any other contractor except with the written consent of the Architect.

6.3.2 Any costs caused by defective or ill-timed work shall be borne by the party responsible therefor.

6.4 OWNER'S RIGHT TO CLEAN UP

6.4.1 If a dispute arises between the separate contractors as to their responsibility for cleaning up as required by Paragraph 4.16, the Owner may clean up and charge the cost thereof to the several contractors as the Architect shall determine to be just.

ARTICLE 7

MISCELLANEOUS PROVISIONS

7.1 GOVERNING LAW

7.1.1 The Contract shall be governed by the law of the place where the Project is located.

7.2 SUCCESSORS AND ASSIGNS

7.2.1 The Owner and the Contractor each binds himself, his partners, successors, assigns and legal representatives to the other party hereto and to the partners, successors, assigns and legal representatives of such other party in respect to all covenants, agreements and obligations contained in the Contract Documents. Neither party to the Contract shall assign the Contract or sublet it as a whole without the written consent of the other, nor shall the Contractor assign any moneys due or to become due to him hereunder, without the previous written consent of the Owner.

7.3 WRITTEN NOTICE

7.3.1 Written notice shall be deemed to have been duly served if delivered in person to the individual or member of the firm or to an officer of the corporation for whom it was intended, or if delivered at or sent by registered or certified mail to the last business address known to him who gives the notice.

7.4 CLAIMS FOR DAMAGES

7.4.1 Should either party to the Contract suffer injury or damage to person or property because of any act or omission of the other party or of any of his employees, agents or others for whose acts he is legally liable, claim shall be made in writing to such other party within a reasonable time after the first observance of such injury or damage.

7.5 PERFORMANCE BOND AND LABOR AND MATERIAL PAYMENT BOND

7.5.1 The Owner shall have the right to require the Contractor to furnish bonds covering the faithful performance of the Contract and the payment of all obligations arising thereunder if and as required in the Instructions to Bidders or elsewhere in the Contract Documents.

7.6 RIGHTS AND REMEDIES

7.6.1 The duties and obligations imposed by the Contract Documents and the rights and remedies available thereunder shall be in addition to and not a limitation of any duties, obligations, rights and remedies otherwise imposed or available by law.

7.7 ROYALTIES AND PATENTS

7.7.1 The Contractor shall pay all royalties and license fees. He shall defend all suits or claims for infringement of any patent rights and shall save the Owner harmless from loss on account thereof, except that the Owner shall be responsible for all such loss when a particular design, process or the product of a particular manufacturer or manufacturers is specified, but if the Contractor has reason to believe that the design, process or product specified is an infringement of a patent, he shall be responsible for such loss unless he promptly gives such information to the Architect.

7.8 TESTS

7.8.1 If the Contract Documents, laws, ordinances, rules, regulations or orders of any public authority having jurisdiction require any Work to be inspected, tested or approved, the Contractor shall give the Architect timely notice of its readiness and of the date arranged so the Architect may observe such inspection, testing or approval. The Contractor shall bear all costs of such inspections, tests and approvals unless otherwise provided.

7.8.2 If after the commencement of the Work the Architect determines that any Work requires special inspection, testing, or approval which Subparagraph 7.8.1

does not include, he will, upon written authorization from the Owner, instruct the Contractor to order such special inspection, testing or approval, and the Contractor shall give notice as in Subparagraph 7.8.1. If such special inspection or testing reveals a failure of the Work to comply (1) with the requirements of the Contract Documents or (2), with respect to the performance of the Work, with laws, ordinances, rules, regulations or orders of any public authority having jurisdiction, the Contractor shall bear all costs thereof, including the Architect's additional services made necessary by such failure; otherwise the Owner shall bear such costs, and an appropriate Change Order shall be issued.

7.8.3 Required certificates of inspection, testing or approval shall be secured by the Contractor and promptly delivered by him to the Architect.

7.8.4 If the Architect wishes to observe the inspections, tests or approvals required by this Paragraph 7.8, he will do so promptly and, where practicable, at the source of supply.

7.8.5 Neither the observations of the Architect in his Administration of the Construction Contract, nor inspections, tests or approvals by persons other than the Contractor shall relieve the Contractor from his obligations to perform the Work in accordance with the Contract Documents.

7.9 INTEREST

7.9.1 Any moneys not paid when due to either party under this Contract shall bear interest at the legal rate in force at the place of the Project.

7.10 ARBITRATION

7.10.1 All claims, disputes and other matters in question arising out of, or relating to, this Contract or the breach thereof, except as set forth in Subparagraph 2.2.9 with respect to the Architect's decisions on matters relating to artistic effect, and except for claims which have been waived by the making or acceptance of final payment as provided by Subparagraphs 9.7.5 and 9.7.6, shall be decided by arbitration in accordance with the Construction Industry Arbitration Rules of the American Arbitration Association then obtaining unless the parties mutually agree otherwise. This agreement to arbitrate shall be specifically enforceable under the prevailing arbitration law. The award rendered by the arbitrators shall be final, and judgment may be entered upon it in accordance with applicable law in any court having jurisdiction thereof.

7.10.2 Notice of the demand for arbitration shall be filed in writing with the other party to the Contract and with the American Arbitration Association, and a copy shall be filed with the Architect. The demand for arbitration shall be made within the time limits specified in Subparagraphs 2.2.10 and 2.2.11 where applicable, and in all other cases within a reasonable time after the claim, dispute or other matter in question has arisen, and in no event shall it be made after the date when institution of legal or equitable proceedings based on such claim, dispute or other matter in question would be barred by the applicable statute of limitations.

7.10.3 The Contractor shall carry on the Work and maintain the progress schedule during any arbitration proceedings, unless otherwise agreed by him and the Owner in writing.

ARTICLE 8

TIME

8.1 DEFINITIONS

8.1.1 The Contract Time is the period of time alloted in the Contract Documents for completion of the Work.

8.1.2 The date of commencement of the Work is the date established in a notice to proceed. If there is no notice to proceed, it shall be the date of the Agreement or such other date as may be established therein.

8.1.3 The Date of Substantial Completion of the Work or designated portion thereof is the Date certified by the Architect when construction is sufficiently complete, in accordance with the Contract Documents, so the Owner may occupy the Work or designated portion thereof for the use for which it is intended.

8.1.4 The term day as used in the Contract Documents shall mean calendar day.

8.2 PROGRESS AND COMPLETION

8.2.1 All time limits stated in the Contract Documents are of the essence of the Contract.

8.2.2 The Contractor shall begin the Work on the date of commencement as defined in Subparagraph 8.1.2. He shall carry the Work forward expeditiously with adequate forces and shall complete it within the Contract Time.

8.2.3 If a date or time of completion is included in the Contract, it shall be the Date of Substantial Completion as defined in Subparagraph 8.1.3, including authorized extensions thereto, unless otherwise provided.

8.3 DELAYS AND EXTENSIONS OF TIME

8.3.1 If the Contractor is delayed at any time in the progress of the Work by any act or neglect of the Owner or the Architect, or by any employee of either, or by any separate contractor employed by the Owner, or by changes ordered in the Work, or by labor disputes, fire, unusual delay in transportation, unavoidable casualties or any causes beyond the Contractor's control, or by delay authorized by the Owner pending arbitration, or by any cause which the Architect determines may justify the delay, then the Contract Time shall be extended by Change Order for such reasonable time as the Architect may determine.

8.3.2 All claims for extension of time shall be made in writing to the Architect no more than twenty days after the occurrence of the delay; otherwise they shall be waived. In the case of a continuing cause of delay only one claim is necessary.

8.3.3 If no schedule or agreement is made stating the dates upon which written interpretations as set forth in Subparagraph 1.2.5 shall be furnished, then no claim for delay shall be allowed on account of failure to furnish such interpretations until fifteen days after demand is made for them, and not then unless such claim is reasonable.

8.3.4 This Paragraph 8.3 does not exclude the recovery of damages for delay by either party under other provisions of the Contract Documents.

ARTICLE 9

PAYMENTS AND COMPLETION

9.1 CONTRACT SUM

9.1.1 The Contract Sum is stated in the Agreement and is the total amount payable by the Owner to the Contractor for the performance of the Work under the Contract Documents.

9.2 SCHEDULE OF VALUES

9.2.1 Before the first Application for Payment, the Contractor shall submit to the Architect a schedule of values of the various portions of the Work, including quantities if required by the Architect, aggregating the total Contract Sum, divided so as to facilitate payments to Subcontractors in accordance with Paragraph 5.4, prepared in such form as specified or as the Architect and the Contractor may agree upon, and supported by such data to substantiate its correctness as the Architect may require. Each item in the schedule of values shall include its proper share of overhead and profit. This schedule, when approved by the Architect, shall be used only as a basis for the Contractor's Applications for Payment.

9.3 PROGRESS PAYMENTS

9.3.1 At least ten days before each progress payment falls due, the Contractor shall submit to the Architect an itemized Application for Payment, supported by such data substantiating the Contractor's right to payment as the Owner or the Architect may require.

9.3.2 If payments are to be made on account of materials or equipment not incorporated in the Work but delivered and suitably stored at the site, or at some other location agreed upon in writing, such payments shall be conditioned upon submission by the Contractor of bills of sale or such other procedures satisfactory to the Owner to establish the Owner's title to such materials or equipment or otherwise protect the Owner's interest including applicable insurance and transportation to the site.

9.3.3 The Contractor warrants and guarantees that title to all Work, materials and equipment covered by an Application for Payment, whether incorporated in the Project or not, will pass to the Owner upon the receipt of such payment by the Contractor, free and clear of all liens, claims, security interests or encumbrances, hereinafter referred to in this Article 9 as "liens"; and that no Work, materials or equipment covered by an Application for Payment will have been acquired by the Contractor; or by any other person performing the Work at the site or furnishing materials and equipment for the Project, subject to an agreement under which an interest therein or an encumbrance thereon is retained by the seller or otherwise imposed by the Contractor or such other person.

9.4 CERTIFICATES FOR PAYMENT

9.4.1 If the Contractor has made Application for Payment as above, the Architect will, with reasonable promptness but not more than seven days after the receipt of the Application, issue a Certificate for Payment to the Owner, with a copy to the Contractor, for such amount as he determines to be properly due, or state in writing his reasons for withholding a Certificate as provided in Subparagraph 9.5.1.

9.4.2 The issuance of a Certificate for Payment will constitute a representation by the Architect to the Owner, based on his observations at the site as provided in Subparagraph 2.2.4 and the data comprising the Application for Payment, that the Work has progressed to the point indicated; that, to the best of his knowledge, information and belief, the quality of the Work is in accordance with the Contract Documents (subject to an evaluation of the Work for conformance with the Contract Documents upon Substantial Completion, to the results of any subsequent tests required by the Contract Documents, to minor deviations from the Contract Documents correctable prior to completion, and to any specific qualifications stated in his Certificate); and that the Contractor is entitled to payment in the amount certified. In addition, the Architect's final Certificate for Payment will constitute a further representation that the conditions precedent to the Contractor's being entitled to final payment as set forth in Subparagraph 9.7.2 have been fulfilled. However, by issuing a Certificate for Payment, the Architect shall not thereby be deemed to represent that he has made exhaustive or continuous on-site inspections to check the quality or quantity of the Work or that he has reviewed the construction means, methods, techniques, sequences or procedures, or that he has made any examination to ascertain how or for what purpose the Contractor has used the moneys previously paid on account of the Contract Sum.

9.4.3 After the Architect has issued a Certificate for Payment, the Owner shall make payment in the manner provided in the Agreement.

9.4.4 No certificate for a progress payment, nor any progress payment, nor any partial or entire use or occupancy of the Project by the Owner, shall constitute an acceptance of any Work not in accordance with the Contract Documents.

9.5 PAYMENTS WITHHELD

9.5.1 The Architect may decline to approve an Application for Payment and may withhold his Certificate in whole or in part, to the extent necessary reasonably to protect the Owner, if in his opinion he is unable to make representations to the Owner as provided in Subparagraph 9.4.2. The Architect may also decline to approve any Applications for Payment or, because of subsequently discovered evidence or subsequent inspections, he may nullify the whole or any part of any Certificate for Payment previously issued, to such extent as may be necessary in his opinion to protect the Owner from loss because of:

.1 defective work not remedied,

.2 third party claims filed or reasonable evidence indicating probable filing of such claims,

.3 failure of the Contractor to make payments properly to Subcontractors or for labor, materials or equipment,
.4 reasonable doubt that the Work can be completed for the unpaid balance of the Contract Sum,
.5 damage to another contractor,
.6 reasonable indication that the Work will not be completed within the Contract Time, or
.7 unsatisfactory prosecution of the Work by the Contractor.

9.5.2 When the above grounds in Subparagraph 9.5.1 are removed, payment shall be made for amounts withheld because of them.

9.6 FAILURE OF PAYMENT

9.6.1 If the Architect should fail to issue any Certificate for Payment, through no fault of the Contractor, within seven days after receipt of the Contractor's Application for Payment, or if the Owner should fail to pay the Contractor within seven days after the date of payment established in the Agreement any amount certified by the Architect or awarded by arbitration, then the Contractor may, upon seven additional days' written notice to the Owner and the Architect, stop the Work until payment of the amount owing has been received.

9.7 SUBSTANTIAL COMPLETION AND FINAL PAYMENT

9.7.1 When the Contractor determines that the Work or a designated portion thereof acceptable to the Owner is substantially complete, the Contractor shall prepare for submission to the Architect a list of items to be completed or corrected. The failure to include any items on such list does not alter the responsibility of the Contractor to complete all Work in accordance with the Contract Documents. When the Architect on the basis of an inspection determines that the Work is substantially complete, he will then prepare a Certificate of Substantial Completion which shall establish the Date of Substantial Completion, shall state the responsibilities of the Owner and the Contractor for maintenance, heat, utilities, and insurance, and shall fix the time within which the Contractor shall complete the items listed therein. The Certificate of Substantial Completion shall be submitted to the Owner and the Contractor for their written acceptance of the responsibilities assigned to them in such Certificate.

9.7.2 Upon receipt of written notice that the Work is ready for final inspection and acceptance and upon receipt of a final Application for Payment, the Architect will promptly make such inspection and, when he finds the Work acceptable under the Contract Documents and the Contract fully performed, he will promptly issue a final Certificate for Payment stating that to the best of his knowledge, information and belief, and on the basis of his observations and inspections, the Work has been completed in accordance with the terms and conditions of the Contract Documents and that the entire balance found to be due the Contractor, and noted in said final Certificate, is due and payable.

9.7.3 Neither the final payment nor the remaining retained percentage shall become due until the Contractor submits to the Architect (1) an Affidavit that all payrolls, bills for materials and equipment, and other indebtedness connected with the Work for which the Owner or his property might in any way be responsible, have been paid or otherwise satisfied, (2) consent of surety, if any, to final payment and (3), if required by the Owner, other data establishing payment or satisfaction of all such obligations, such as receipts, releases and waivers of liens arising out of the Contract, to the extent and in such form as may be designated by the Owner. If any Subcontractor refuses to furnish a release or waiver required by the Owner, the Contractor may furnish a bond satisfactory to the Owner to indemnify him against any such lien. If any such lien remains unsatisfied after all payments are made, the Contractor shall refund to the Owner all moneys that the latter may be compelled to pay in discharging such lien, including all costs and reasonable attorneys' fees.

9.7.4 If after Substantial Completion of the Work final completion thereof is materially delayed through no fault of the Contractor, and the Architect so confirms, the Owner shall, upon certification by the Architect, and without terminating the Contract, make payment of the balance due for that portion of the Work fully completed and accepted. If the remaining balance for Work not fully completed or corrected is less than the retainage stipulated in the Agreement, and if bonds have been furnished as required in Subparagraph 7.5.1, the written consent of the surety to the payment of the balance due for that portion of the Work fully completed and accepted shall be submitted by the Contractor to the Architect prior to certification of such payment. Such payment shall be made under the terms and conditions governing final payment, except that it shall not constitute a waiver of claims.

9.7.5 The making of final payment shall constitute a waiver of all claims by the Owner except those arising from:
.1 unsettled liens,
.2 faulty or defective Work appearing after Substantial Completion,
.3 failure of the Work to comply with the requirements of the Contract Documents, or
.4 terms of any special guarantees required by the Contract Documents.

9.7.6 The acceptance of final payment shall constitute a waiver of all claims by the Contractor except those previously made in writing and still unsettled.

ARTICLE 10

PROTECTION OF PERSONS AND PROPERTY

10.1 SAFETY PRECAUTIONS AND PROGRAMS

10.1.1 The Contractor shall be responsible for initiating, maintaining and supervising all safety precautions and programs in connection with the Work.

10.2 SAFETY OF PERSONS AND PROPERTY

10.2.1 The Contractor shall take all reasonable precautions for the safety of, and shall provide all reasonable protection to prevent damage, injury or loss to:

.1 all employees on the Work and all other persons who may be affected thereby;
.2 all the Work and all materials and equipment to be incorporated therein, whether in storage on or off the site, under the care, custody or control of the Contractor or any of his Subcontractors or Sub-subcontractors; and
.3 other property at the site or adjacent thereto, including trees, shrubs, lawns, walks, pavements, roadways, structures and utilities not designated for removal, relocation or replacement in the course of construction.

10.2.2 The Contractor shall comply with all applicable laws, ordinances, rules, regulations and lawful orders of any public authority having jurisdiction for the safety of persons or property or to protect them from damage, injury or loss. He shall erect and maintain, as required by existing conditions and progress of the Work, all reasonable safeguards for safety and protection, including posting danger signs and other warnings against hazards, promulgating safety regulations and notifying owners and users of adjacent utilities.

10.2.3 When the use or storage of explosives or other hazardous materials or equipment is necessary for the execution of the Work, the Contractor shall exercise the utmost care and shall carry on such activities under the supervision of properly qualified personnel.

10.2.4 All damage or loss to any property referred to in Clauses 10.2.1.2 and 10.2.1.3 caused in whole or in part by the Contractor, any Subcontractor, any Sub-subcontractor, or anyone directly or indirectly employed by any of them, or by anyone for whose acts any of them may be liable, shall be remedied by the Contractor, except damage or loss attributable to faulty Drawings or Specifications or to the acts or omissions of the Owner or Architect or anyone employed by either of them or for whose acts either of them may be liable, and not attributable to the fault or negligence of the Contractor.

10.2.5 The Contractor shall designate a responsible member of his organization at the site whose duty shall be the prevention of accidents. This person shall be the Contractor's superintendent unless otherwise designated in writing by the Contractor to the Owner and the Architect.

10.2.6 The Contractor shall not load or permit any part of the Work to be loaded so as to endanger its safety.

10.3 EMERGENCIES

10.3.1 In any emergency affecting the safety of persons or property, the Contractor shall act, at his discretion, to prevent threatened damage, injury or loss. Any additional compensation or extension of time claimed by the Contractor on account of emergency work shall be determined as provided in Article 12 for Changes in the Work.

ARTICLE 11

INSURANCE

11.1 CONTRACTOR'S LIABILITY INSURANCE

11.1.1 The Contractor shall purchase and maintain such insurance as will protect him from claims set forth below which may arise out of or result from the Contractor's operations under the Contract, whether such operations be by himself or by any Subcontractor or by anyone directly or indirectly employed by any of them, or by anyone for whose acts any of them may be liable:

.1 claims under workmen's compensation, disability benefit and other similar employee benefit acts;
.2 claims for damages because of bodily injury, occupational sickness or disease, or death of his employees;
.3 claims for damages because of bodily injury, sickness or disease, or death of any person other than his employees;
.4 claims for damages insured by usual personal injury liability coverage which are sustained (1) by any person as a result of an offense directly or indirectly related to the employment of such person by the Contractor, or (2) by any other person; and
.5 claims for damages because of injury to or destruction of tangible property, including loss of use resulting therefrom.

11.1.2 The insurance required by Subparagraph 11.1.1 shall be written for not less than any limits of liability specified in the Contract Documents, or required by law, whichever is greater, and shall include contractual liability insurance as applicable to the Contractor's obligations under Paragraph 4.18.

11.1.3 Certificates of Insurance acceptable to the Owner shall be filed with the Owner prior to commencement of the Work. These Certificates shall contain a provision that coverages afforded under the policies will not be cancelled until at least fifteen days' prior written notice has been given to the Owner.

11.2 OWNER'S LIABILITY INSURANCE

11.2.1 The Owner shall be responsible for purchasing and maintaining his own liability insurance and, at his option, may purchase and maintain such insurance as will protect him against claims which may arise from operations under the Contract.

11.3 PROPERTY INSURANCE

11.3.1 Unless otherwise provided, the Owner shall purchase and maintain property insurance upon the entire Work at the site to the full insurable value thereof. This insurance shall include the interests of the Owner, the Contractor, Subcontractors and Sub-subcontractors in the Work and shall insure against the perils of Fire, Extended Coverage, Vandalism and Malicious Mischief.

11.3.2 The Owner shall purchase and maintain such steam boiler and machinery insurance as may be required by the Contract Documents or by law. This insurance shall include the interests of the Owner, the Contractor, Subcontractors and Sub-subcontractors in the Work.

11.3.3 Any insured loss is to be adjusted with the Owner and made payable to the Owner as trustee for the insureds, as their interests may appear, subject to the requirements of any applicable mortgagee clause and of Subparagraph 11.3.8.

11.3.4 The Owner shall file a copy of all policies with the Contractor before an exposure to loss may occur. If the Owner does not intend to purchase such insurance, he shall inform the Contractor in writing prior to commencement of the Work. The Contractor may then effect insurance which will protect the interests of himself, his Subcontractors and the Sub-subcontractors in the Work, and by appropriate Change Order the cost thereof shall be charged to the Owner. If the Contractor is damaged by failure of the Owner to purchase or maintain such insurance and so to notify the Contractor, then the Owner shall bear all reasonable costs properly attributable thereto.

11.3.5 If the Contractor requests in writing that insurance for special hazards be included in the property insurance policy, the Owner shall, if possible, include such insurance, and the cost thereof shall be charged to the Contractor by appropriate Change Order.

11.3.6 The Owner and Contractor waive all rights against each other for damages caused by fire or other perils to the extent covered by insurance provided under this Paragraph 11.3, except such rights as they may have to the proceeds of such insurance held by the Owner as trustee. The Contractor shall require similar waivers by Subcontractors and Sub-subcontractors in accordance with Clause 5.3.1.5.

11.3.7 If required in writing by any party in interest, the Owner as trustee shall, upon the occurrence of an insured loss, give bond for the proper performance of his duties. He shall deposit in a separate account any money so received, and he shall distribute it in accordance with such agreement as the parties in interest may reach, or in accordance with an award by arbitration in which case the procedure shall be as provided in Paragraph 7.10. If after such loss no other special agreement is made, replacement of damaged work shall be covered by an appropriate Change Order.

11.3.8 The Owner as trustee shall have power to adjust and settle any loss with the insurers unless one of the parties in interest shall object in writing within five days after the occurrence of loss to the Owner's exercise of this power, and if such objection be made, arbitrators shall be chosen as provided in Paragraph 7.10. The Owner as trustee shall, in that case, make settlement with the insurers in accordance with the directions of such arbitrators. If distribution of the insurance proceeds by arbitration is required, the arbitrators will direct such distribution.

11.4 LOSS OF USE INSURANCE

11.4.1 The Owner, at his option, may purchase and maintain such insurance as will insure him against loss of use of his property due to fire or other hazards, however caused.

ARTICLE 12

CHANGES IN THE WORK

12.1 CHANGE ORDERS

12.1.1 The Owner, without invalidating the Contract, may order Changes in the Work within the general scope of the Contract consisting of additions, deletions or other revisions, the Contract Sum and the Contract Time being adjusted accordingly. All such Changes in the Work shall be authorized by Change Order, and shall be executed under the applicable conditions of the Contract Documents.

12.1.2 A Change Order is a written order to the Contractor signed by the Owner and the Architect, issued after the execution of the Contract, authorizing a Change in the Work or an adjustment in the Contract Sum or the Contract Time. Alternatively, the Change Order may be signed by the Architect alone, provided he has written authority from the Owner for such procedure and that a copy of such written authority is furnished to the Contractor upon request. A Change Order may also be signed by the Contractor if he agrees to the adjustment in the Contract Sum or the Contract Time. The Contract Sum and the Contract Time may be changed only by Change Order.

12.1.3 The cost or credit to the Owner resulting from a Change in the Work shall be determined in one or more of the following ways:

.1 by mutual acceptance of a lump sum properly itemized;

.2 by unit prices stated in the Contract Documents or subsequently agreed upon; or

.3 by cost and a mutually acceptable fixed or percentage fee.

12.1.4 If none of the methods set forth in Subparagraph 12.1.3 is agreed upon, the Contractor, provided he receives a Change Order, shall promptly proceed with the Work involved. The cost of such Work shall then be determined by the Architect on the basis of the Contractor's reasonable expenditures and savings, including, in the case of an increase in the Contract Sum, a reasonable allowance for overhead and profit. In such case, and also under Clause 12.1.3.3 above, the Contractor shall keep and present, in such form as the Architect may prescribe, an itemized accounting together with appropriate supporting data. Pending final determination of cost to the Owner, payments on account shall be made on the Architect's Certificate for Payment. The amount of credit to be allowed by the Contractor to the Owner for any deletion or change which results in a net decrease in cost will be the amount of the actual net decrease as confirmed by the Architect. When both additions and credits are involved in any one change, the allowance for overhead and profit shall be figured on the basis of net increase, if any.

12.1.5 If unit prices are stated in the Contract Documents or subsequently agreed upon, and if the quantities originally contemplated are so changed in a proposed Change Order that application of the agreed unit prices to the quantities of Work proposed will create a hardship on the Owner or the Contractor, the applicable unit prices shall be equitably adjusted to prevent such hardship.

12.1.6 Should concealed conditions encountered in the performance of the Work below the surface of the ground be at variance with the conditions indicated by the Contract Documents or should unknown physical conditions below the surface of the ground of an unusual nature, differing materially from those ordinarily encountered and generally recognized as inherent in work of the character provided for in this Contract, be encountered, the Contract Sum shall be equitably adjusted by Change Order upon claim by either party made within twenty days after the first observance of the conditions.

12.1.7 If the Contractor claims that additional cost is involved because of (1) any written interpretation issued pursuant to Subparagraph 1.2.5, (2) any order by the Owner to stop the Work pursuant to Paragraph 3.3 where the Contractor was not at fault, or (3) any written order for a minor change in the Work issued pursuant to Paragraph 12.3, the Contractor shall make such claim as provided in Paragraph 12.2.

12.2 CLAIMS FOR ADDITIONAL COST

12.2.1 If the Contractor wishes to make a claim for an increase in the Contract Sum, he shall give the Architect written notice thereof within twenty days after the occurrence of the event giving rise to such claim. This notice shall be given by the Contractor before proceeding to execute the Work, except in an emergency endangering life or property in which case the Contractor shall proceed in accordance with Subparagraph 10.3.1. No such claim shall be valid unless so made. If the Owner and the Contractor cannot agree on the amount of the adjustment in the Contract Sum, it shall be determined by the Architect. Any change in the Contract Sum resulting from such claim shall be authorized by Change Order.

12.3 MINOR CHANGES IN THE WORK

12.3.1 The Architect shall have authority to order minor changes in the Work not involving an adjustment in the Contract Sum or an extension of the Contract Time and not inconsistent with the intent of the Contract Documents. Such changes may be effected by Field Order or by other written order. Such changes shall be binding on the Owner and the Contractor.

12.4 FIELD ORDERS

12.4.1 The Architect may issue written Field Orders which interpret the Contract Documents in accordance with Subparagraph 1.2.5 or which order minor changes in the Work in accordance with Paragraph 12.3 without change in Contract Sum or Contract Time. The Contractor shall carry out such Field Orders promptly.

ARTICLE 13

UNCOVERING AND CORRECTION OF WORK

13.1 UNCOVERING OF WORK

13.1.1 If any Work should be covered contrary to the request of the Architect, it must, if required by the Architect, be uncovered for his observation and replaced, at the Contractor's expense.

13.1.2 If any other Work has been covered which the Architect has not specifically requested to observe prior to being covered, the Architect may request to see such Work and it shall be uncovered by the Contractor. If such Work be found in accordance with the Contract Documents, the cost of uncovering and replacement shall, by appropriate Change Order, be charged to the Owner. If such Work be found not in accordance with the Contract Documents, the Contractor shall pay such costs unless it be found that this condition was caused by a separate contractor employed as provided in Article 6, and in that event the Owner shall be responsible for the payment of such costs.

13.2 CORRECTION OF WORK

13.2.1 The Contractor shall promptly correct all Work rejected by the Architect as defective or as failing to conform to the Contract Documents whether observed before or after Substantial Completion and whether or not fabricated, installed or completed. The Contractor shall bear all cost of correcting such rejected Work, including the cost of the Architect's additional services thereby made necessary.

13.2.2 If, within one year after the Date of Substantial Completion or within such longer period of time as may be prescribed by law or by the terms of any applicable special guarantee required by the Contract Documents, any of the Work is found to be defective or not in accordance with the Contract Documents, the Contractor shall correct it promptly after receipt of a written notice from the Owner to do so unless the Owner has previously given the Contractor a written acceptance of such condition. The Owner shall give such notice promptly after discovery of the condition.

13.2.3 All such defective or non-conforming Work under Subparagraphs 13.2.1 and 13.2.2 shall be removed from the site if necessary, and the Work shall be corrected to comply with the Contract Documents without cost to the Owner.

13.2.4 The Contractor shall bear the cost of making good all work of separate contractors destroyed or damaged by such removal or correction.

13.2.5 If the Contractor does not remove such defective or non-conforming Work within a reasonable time fixed by written notice from the Architect, the Owner may remove it and may store the materials or equipment at the expense of the Contractor. If the Contractor does not pay the cost of such removal and storage within ten days thereafter, the Owner may upon ten additional days' written notice sell such Work at auction or at private sale and shall account for the net proceeds thereof, after deducting all the costs that should have been borne by the Contractor including compensation for additional architectural services. If such proceeds of sale do not cover all costs which the Contractor should have borne, the difference shall be charged to the Contractor and an appropriate Change Order shall be issued. If the payments then or thereafter due the Contractor are not sufficient to cover such amount, the Contractor shall pay the difference to the Owner.

13.2.6 If the Contractor fails to correct such defective or non-conforming Work, the Owner may correct it in accordance with Paragraph 3.4.

13.3 ACCEPTANCE OF DEFECTIVE OR NON-CONFORMING WORK

13.3.1 If the Owner prefers to accept defective or non-conforming Work, he may do so instead of requiring its removal and correction; in which case a Change Order will be issued to reflect an appropriate reduction in the Contract Sum, or, if the amount is determined after final payment, it shall be paid by the Contractor.

ARTICLE 14

TERMINATION OF THE CONTRACT

14.1 TERMINATION BY THE CONTRACTOR

14.1.1 If the Work is stopped for a period of thirty days under an order of any court or other public authority having jurisdiction, or as a result of an act of government, such as a declaration of a national emergency making materials unavailable, through no act or fault of the Contractor or a Subcontractor or their agents or employees or any other persons performing any of the Work under a contract with the Contractor, or if the Work should be stopped for a period of thirty days by the Contractor for the Architect's failure to issue a Certificate for Payment as provided in Paragraph 9.6 or for the Owner's failure to make payment thereon as provided in Paragraph 9.6, then the Contractor may, upon seven days' written notice to the Owner and the Architect, terminate the Contract and recover from the Owner payment for all Work executed and for any proven loss sustained upon any materials, equipment, tools, construction equipment and machinery, including reasonable profit and damages.

14.2 TERMINATION BY THE OWNER

14.2.1 If the Contractor is adjudged a bankrupt, or if he makes a general assignment for the benefit of his creditors, or if a receiver is appointed on account of his insolvency, or if he persistently or repeatedly refuses or fails, except in cases for which extension of time is provided, to supply enough properly skilled workmen or proper materials, or if he fails to make prompt payment to Subcontractors or for materials or labor, or persistently disregards laws, ordinances, rules, regulations or orders of any public authority having jurisdiction, or otherwise is guilty of a substantial violation of a provision of the Contract Documents, then the Owner, upon certification by the Architect that sufficient cause exists to justify such action, may, without prejudice to any right or remedy and after giving the Contractor and his surety, if any, seven days' written notice, terminate the employment of the Contractor and take possession of the site and of all materials, equipment, tools, construction equipment and machinery thereon owned by the Contractor and may finish the Work by whatever method he may deem expedient. In such case the Contractor shall not be entitled to receive any further payment until the Work is finished.

14.2.2 If the unpaid balance of the Contract Sum exceeds the costs of finishing the Work, including compensation for the Architect's additional services, such excess shall be paid to the Contractor. If such costs exceed such unpaid balance, the Contractor shall pay the difference to the Owner. The costs incurred by the Owner as herein provided shall be certified by the Architect.

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